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# CAM HIGHLIGHTS

(FY 80)

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PREPARED BY

OCTOBER 1980

USA INDUSTRIAL BASE ENGINEERING ACTIVITY

MANUFACTURING TECHNOLOGY DIVISION

ROCK ISLAND, ILLINOIS 61299

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Highlights	Manufacturing Methods											
Technology Transfer	Manufacturing Technology											
Manufacturing Methods and Technology ✓	CAM Program											
DARCOM	Major Army Systems											
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)												
<p>This document contains summaries of 60 Army Computer Aided Manufacturing (CAM) efforts that are either completed or on-going. The Army CAM Program funds efforts through manufacturing technology, facilities or major systems contracts.</p> <p>Significant information contained in this document was obtained from various management documents submitted to IBEA during the life cycle of the efforts. DARCOM Subordinate Major Commands, Installations, Activities and Program Offices are the sources for this management data.</p>												

20. The summaries highlight the integration of computers in manufacturing and are organized into eleven sections for this document. These eleven sections correspond to system technology areas which are listed with their numerical classification number.

TECHNOLOGY  
AREA NUMBER

TECHNOLOGY AREA TITLE

100	Architecture
200	Fabrication
300	Data Base/Data Automation
400	CAD/CAM Interaction
500	Planning and Group Technology
600	Manufacturing Control
700	Assembly
800	Simulation, Modeling and Operations Research
900	Materials Handling and Storage
1000	Test, Inspection and Evaluation
1100	Continuous Flow Processes

Applications for the control systems covered by the summaries include: Metal Working such as machining, joining and forming; Electronics applications such as Printed Wiring Boards, Integrated Circuits, Very Large Scale Integrated Circuits; Inspection; and Chemical processing.

The typical facilities addressed by the summaries include: contractor owned and contractor operated, plants for shell manufacturers, and turbine engines; Government owned and contractor operated, plants such as ammunition plants, and tank plants; Government owned and Government operated plants, such as arsenals and Ammunition Plants.

A brief synopsis of each CAM Manufacturing Technology and Facilitization effort depicting cost, years of funding, points of contact, etc., is listed in appendix A. The link between the reference to an effort in the body of the report and the effort listing in the appendix is a four digit effort number typically shown in parentheses.



DEPARTMENT OF THE ARMY  
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY  
ROCK ISLAND, ILLINOIS 61299

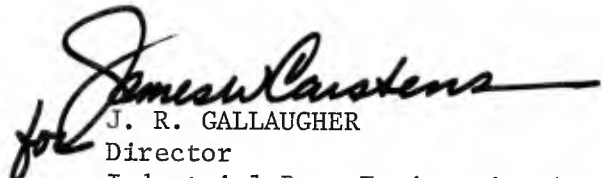
DRXIB-MT

25 September 1980

SUBJECT: Computer Aided Manufacturing (CAM) Highlights

SEE DISTRIBUTION

1. Reference DARCOM-R 15-13, "DARCOM Computer Aided Manufacturing (CAM) Steering Group," dated 3 June 1977.
2. The CAM Highlights presents summaries of 60 Army CAM efforts that are either completed or on-going. The Army Procurement Appropriations funded these efforts through manufacturing technology, facilities or major systems contracts. The document was prepared under the auspices of DARCOM-R 15-13, and represents a compilation of efforts up to October 1980. Information presented was obtained from various management documents submitted to IBEA during the life cycle of the efforts and through follow-up material supplied by the program proponents.
3. Comments on this material may be sent to the CAM Steering Group chairman, Mr. Stephen McGlone, US Army Industrial Base Engineering Activity, DRXIB-MT, Rock Island, IL, 61299. Additional copies may be obtained by written request to the Defense Technical Information Center, Attn: TSR-I, Cameron Station, Alexandria, VA, 22314.

  
J. R. GALLAUGHER  
Director  
Industrial Base Engineering Activity

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This document presents information for the US Army Materiel Development and Readiness Command (DARCOM) Computer Aided Manufacturing (CAM) Program.

The projects listed and the dollar amounts shown for projects which are not completed are provided for discussion purposes only, and not as information useable in pricing or contracting for the work.

The projects listed and the dollar amounts shown for projects which are not funded are subject to change without notice. Headquarters, DARCOM and its subordinate major commands and centers have the authority to reprogram funds to projects with higher priority, thereby affording the flexibility to accommodate new opportunities as they arise. Users of this document are encouraged to offer suggestions for additional projects which would benefit the production of Army materiel.

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# SUMMARY

The CAM Highlights describes Army efforts using Computer Aided Manufacturing (CAM) to upgrade its industrial base. Improvements in productivity and quality of products were obtained through the integration of computers in manufacturing. The document provides information describing efforts and points of contact for additional information.

Some efforts were initiated with Manufacturing Methods and Technology (MMT) projects and have follow-on Provision of Industrial Facility (PIF) projects for implementation. Of the MMT efforts discussed in this document at least seven have been pacing efforts to follow-on Facility efforts. Other efforts are initiated with only PIF projects for their implementation (e.g. Lone Star Army Ammunition Plant Robotics Application). While still other efforts are implemented under major systems contracts either separately or in conjunction with MMT or PIF projects (e.g. XM1 Tank). All efforts presented were funded through the Army Procurement Appropriation and are representative of efforts pursued through the Army CAM program.

The efforts described highlight the integration of computers in manufacturing and are organized into eleven sections for this document. These eleven sections correspond to system technology areas which are listed in Exhibit 1 with their numerical classification number, along with the number of efforts presented in each area.

## SUMMARY OF CAM HIGHLIGHTS

<u>TECHNOLOGY AREA NUMBER</u>	<u>NUMBER OF CAM EFFORTS</u>				<u>TECHNOLOGY AREA TITLE</u>
	<u>Total</u>	<u>MMT</u>	<u>PIF</u>	<u>Other</u>	
100	3	3	0	0	Architecture
200	15	9	4	2	Fabrication
300	3	3	0	0	Data Base/Data Automation
400	11	11	0	0	CAD/CAM Interaction
500	7	6	1	0	Planning and Group Technology
600	6	4	2	0	Manufacturing Control
700	3	1	2	0	Assembly
800	2	2	0	0	Simulation, Model & Operations Rsch
900	3	2	1	0	Materials Handling and Storage
1000	3	3	0	0	Test, Inspection and Evaluation
1100	4	4	0	0	Continuous Flow Processes
Total	60	48	10	2	

## EXHIBIT 1

The technology areas where the largest number of efforts have been presented are 200 - Fabrication, 400 - CAD/CAM Interaction, 500 - Planning and Group Technology, and 600 - Manufacturing Control.



Cost savings and productivity measures were difficult to obtain but are included where they were verifiable. Quantitative and qualitative benefits are being addressed in follow-on Effectiveness Reports published annually.

Efforts are presented in summary format and cover a wide spectrum of CAM applications. Summaries of the 60 Army CAM efforts represent either completed or on-going efforts. CAM efforts were funded by manufacturing technology, facilities or major systems contracts. Applications for the control systems addressed in the summaries include: Metal Working, such as machining, joining, and forming; Electronics applications such as Printed Wiring Boards, Integrated Circuits, Very Large Scale Integrated Circuits; Inspection; and Chemical processes.

In maintaining inventories, Numerical Control (NC) machine tools are usually identified separate from the computers, controllers and software that support them. NC machines make a significant contribution to the production capacity of the Army's industrial base and represent a sizable dollar investment. The Army NC inventory consists of 476 machines having an acquisition cost of \$95 million dollars. The 476 NC machines represent approximately 1% of the total Army metal working equipment. During the past two years, 74% of the new Army NC machine tools have been procured in support of the XML Tank facilities. In addition, efforts to rehabilitate and retrofit NC machine tools are on-going through Army PIF funding.

The number of NC machine tools in the Army are shown grouped into eight machine classes in exhibit 2. Additional points of contact, from whom CAM information may be acquired, are listed in the Appendix B under the title "Computer Aided Manufacturing Steering Group Representatives." A summary of DARCOM main frame and minicomputer CAD/CAM capabilities is listed in Appendix C.

#### ARMY NUMERICAL CONTROL MACHINE TOOLS

<u>MACHINE CLASS</u>	<u>NUMERICAL CONTROL MACHINE QUANTITY</u>
Boring	111
Drilling	45
Turning	127
Milling	58
Machining Centers	121
Punching	11
Grinding	2
Forging	1
	<hr/>
Total	476

#### EXHIBIT 2

# INTRODUCTION

The United States is being challenged by other industrialized nations in almost every manufacturing market place. Many foreign nation's manufacturing advancements have resulted from exploiting concepts that American manufacturers have developed, but for some reason have failed to apply to improve their own productivity.

The results of a study performed in 1977 by the National Science Foundation (NSF) on innovations in the United States estimates that technological innovations were responsible for 45% of our nations economic growth from years 1929 to 1969. It was also found that high technology industries outstripped other industries by two to one in productivity rate increases, with nine times more growth in employment, while product price increases were six times fewer.

Other industrialized nations such as Japan and West Germany are improving their productivity by advancing Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) to their products and to their machine tools. The US Army and the other Military departments have, for the last two decades, been energetically supporting advancements in computer aided applications to the design and manufacturing of weapon systems. Army CAD/CAM support has been directed through the Manufacturing Technology Program and the Provision of Industrial Facilities Program. Army's CAM applications have occurred on the XM1 tank, M2 and M3 combat vehicles, computer applications for ammunition continuous flow production, and many others.

Innovative and industry leading advancements by US electronic manufacturers in the field of microelectronics has had the effect to lower the price of computing and made it possible for virtually every electrically driven machine tool to be controlled by a computer or microprocessor. Products along with the machine tools are also taking advantage of microprocessors. As the trend toward less costly and smaller microprocessors continues and capacity increases, electronic applications on products, machine tools and their associated equipment will also grow. The US Army is working to meet the challenge of taking advantage of these technological advances through its on-going modernization programs.

Eleven technology areas are used to classify, describe, and analyze CAM efforts in this report. Each effort has been categorized into one of the following technology areas. These areas were originally identified in the Air Force Integrated Computer Aided Manufacturing (ICAM) Program. Refinements were included by the Manufacturing Technology Advisory Group (MTAG) CAD/CAM Subcommittee. Utilizing these CAM technology areas provides a systematic structure for directing thinking toward an integrated systems approach. These technology areas represent the "system" and are defined as follows:

## 100 ARCHITECTURE

The purpose of the manufacturing architecture is to provide a clear understanding of the manufacturing environment and the interrelationships between subsystems that exist today. The manufacturing architecture, or framework provides a common baseline in building integrated manufacturing systems.

## 200 FABRICATION

The fabrication technology area serves as a focus for all other technology area activities. Projects categorized into this area are directed toward increasing the productivity of manufacturing by systematically applying computer technology to all functions which directly and indirectly participate in fabricating parts.

## 300 DATA BASE/DATA AUTOMATION

Data base and data automation technology required to support integration of the many stages and disciplines of manufacturing.

## 400 CAD/CAM INTERACTION

The purpose of this technology thrust area is to establish subsystems and procedures which will integrate the efforts of product design and manufacturing. The underlying concept is that of a common data base between engineering and manufacturing.

## 500 PLANNING AND GROUP TECHNOLOGY

Technology directed at optimizing process planning, production scheduling and control, factory layout and other tasks normally performed by indirect personnel that have a significant impact on manufacturing cost.

## 600 MANUFACTURING CONTROL

Generic technology for producing management oriented information tools for scheduling, monitoring and controlling operations within the manufacturing environment. Closely related to the fabrication and planning and group technology areas.

## 700 ASSEMBLY

The integration of computer aided technology into assembly operations.

## 800 SIMULATION, MODELING AND OPERATIONS RESEARCH

Soft technology for optimizing manufacturing systems through the application of operations research techniques.

## 900 MATERIALS HANDLING AND STORAGE

The integration of computer aided technology to aid in material handling. Objectives here include complying with OSHA and EPA standards and reducing costs and materials handling time through automated material storage, handling, and retrieval systems.

## 1000 TEST, INSPECTION AND EVALUATION

Develop and transition real time, computerized, nondestructive testing techniques for use in fabrication and assembly operations. Emphasis is put on automatic, in-process inspection and decision making without human intervention.

## 1100 CONTINUOUS FLOW PROCESSES

This technology area addresses the range of manufacturing processes that, for the most part, are continuous with minimum human interaction.

The first technology area "Architecture" establishes the structure into which the other ten technology areas will be integrated.

# HIGHLIGHTS

## **100 ARCHITECTURE**

Electronic Computer Aided Manufacturing

Hybrid Integrated CAD/CAM

Computer Integrated Manufacturing



# 100 ARCHITECTURE

## CAM MODEL

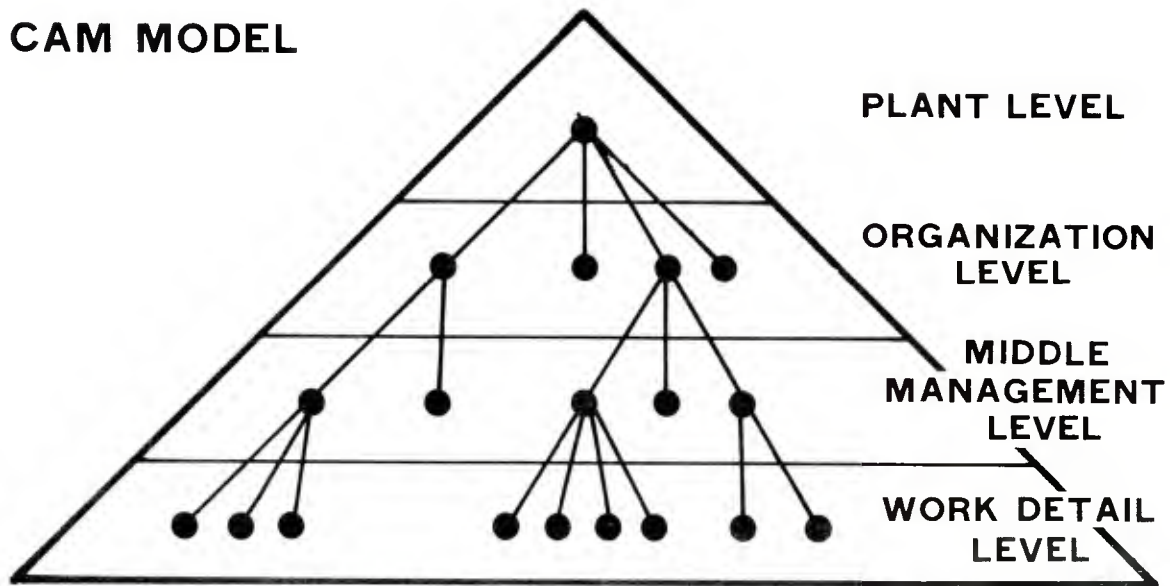


Figure 1

The purpose of the manufacturing architecture is to provide a clear understanding of the manufacturing environment and the interrelationships between subsystems that exist today. The manufacturing architecture, or framework provides a common baseline upon which integrated manufacturing systems can be built.

The architecture provides an installation, a plant or management level a framework into which individual modules of CAM accomplishments will be integrated for total disciplined manufacturing operation and control. An example of the framework is illustrated for several levels of the manufacturing operation in Figure 1.

The integration of all levels of CAM from the work detailed level to the top management or facilities level is not an easy task to accomplish. Total integration requires persistent visualization of each subsystem into a hierarchial framework of all subsystems.

## **ELECTRONIC COMPUTER AIDED MANUFACTURING**

The US Army Missile Command (MICOM) is currently supporting an MMT effort (1075) to plan the architecture for the integration or compatibility between the various CAM systems for electronics equipment.

This effort is intended to provide an architecture, software plan of a complete CAD/CAM electronics design and manufacturing capability to support Tri-Service use. The DOD industrial base maintains many computer systems that aid in the design and manufacture of commercial and military electronics. These systems are typically independent of each other with some interfaces developed on a patchwork basis. This lack of overall system operation, degrades the quality of manufacturing information supplied by the systems and causes implementation of new CAM applications to be costly and time consuming. Utilizing a top down hierarchical approach this ongoing effort will use lessons learned from the Air Force ICAM (Integrated Computer Aided Manufacturing) methodologies, NASA's IPAD (Integrated Program for Aerospace-Vehicle Design), applicable DOD MANTECH (Manufacturing Technology) projects and other necessary data in order to define the CAM and electronic technologies' total integration effort. The effort will concentrate on developing a plan defining the most applicable areas of defense related electronics manufacturing such as integrated circuits, printed circuit boards, hybrid microelectronics, chassis, cable harness, and wire-wound components.

To achieve maximum benefits this effort will develop a master plan for the electronic CAM area using a system structure approach that includes design, manufacturing and testing.

The follow on implementation in computer aided manufacturing as defined by this effort's plan will be performed in the FY 82-85 time frame.

Additional information about this effort may be obtained by contacting Mr. Gordon Little, MICOM, Autovon 746-3848 or Commercial (205) 876-3848.

## **HYBRID INTEGRATED CAD/CAM**

In addition to the ECAM effort (1075) the US Army MICOM is also currently supporting an MMT effort (1071) to plan the architecture for integrating computer aided design and computer aided manufacturing to hybrid microelectronics.

Hybrid electronics offers significant benefits in terms of reduced weight, volume and power consumption. Hybrid electronics manufacturing process is labor intensive resulting in high cost. Although some progress has been made in automating areas of design and manufacturing, little progress has been made in the integration of the design and manufacture of hybrids. There is a need for a coordinated effort to take advantage of the maximum benefits of the great potential of a computer integrated design base.

This effort (1071) will focus on an analysis of the functional flow and the manufacturing process of hybrid technology. The results will identify all available equipment and processes in industry and Government which are capable of meeting DOD computer integrated design and manufacturing needs. Also identified will be those areas where manufacturing technology is inadequate or still missing. This effort will be coordinated with the Manufacturing Technology Advisory Group (MTAG) Electronics and CAD/CAM Subcommittees interface group. The end product of this effort will be a detailed plan that will include a list of the necessary projects, schedules and funding levels required to achieve a fully computer integrated system. After completion of this effort, implementation will be coordinated by the MICOM Man-Tech office for use by Government and industry. This effort will be coordinated with progress of the MMT effort 1075 titled "Electronics Computer Aided Manufacturing."

Additional information about this effort may be obtained by contacting Mr. Gordon Little, MICOM, Autovon 746-3848 or Commercial (205) 876-3848.

## COMPUTER INTEGRATED MANUFACTURING

The US Army Armament Research and Development Command is currently supporting an MMT effort (6736) to accelerate technical readiness through computer integrated manufacturing (TRACIM). This effort is aimed at reducing delays and lead time required to bring ammunition production lines up to mobilization requirements. Delays and long lead times are being paced by the ever increasing shortages of highly skilled manufacturing craftsmen, including engineers, technicians and particularly toolmakers and machinists. Many of these skilled personnel are retiring from the work force and not being replaced. Significant delay factors include the capability to complete and keep current requirements on the item description, manufacturing process, tool designs, equipment, facilities, machine spare parts, material requirements and essential personnel.

This effort intends to reduce the requirements for highly skilled manufacturing craftsmen, as they retire, through utilization of computer programmed numerical control equipment to perform critical functions. The effort also is directed towards planning a computerized data storage and retrieval system based on Group Technology (GT) principles. The data storage and retrieval system will provide rapid access to fully maintained manufacturing data required for rapid buildup to support maximum mobilization schedules.

This effort was begun in 1976 and has to date accomplished several tasks: analyzed two metal parts contractors' manufacturing data packages, developed a definition of data base input criteria, processed selected tooling data into the TRACIM computer data base via Interactive Graphics, generated Numerical Control (NC) machine tool programs through a mini-computer, and fabricated the tooling on a NC precision lathe. An additional task provided by a contractor has developed the initial Architecture diagrams covering the manufacturing structure of the two metal parts procedures. One component path of each hierarchical tree has been prepared and is being reviewed.

The end product of this effort is intended to be a comprehensive computer integrated manufacturing system which will be demonstrated on samples of on-going metal parts and items in the planning stage. The system is also intended to be applicable to the entire spectrum of ammunition design/manufacture. It is anticipated that software interfaces will have to be established between Control Data Corp. (Dover, NJ) system and other computer systems within the Army industrial base.

Additional information may be obtained by contacting Mr. Stanley S. Hart, ARRADCOM, Autovon 880-3721 or Commercial (201) 328-3721.

## **200 FABRICATION**

Numerical Control Language Evaluation

Blisk and Impeller Fabrication

High Speed Data Collection and Control

CAM Applications for the XMI Tank

Flexible Machining Systems

Rotating Band Welding

Electron Beam Fabrication of Integrated Circuits

Night Vision



## 200 FABRICATION

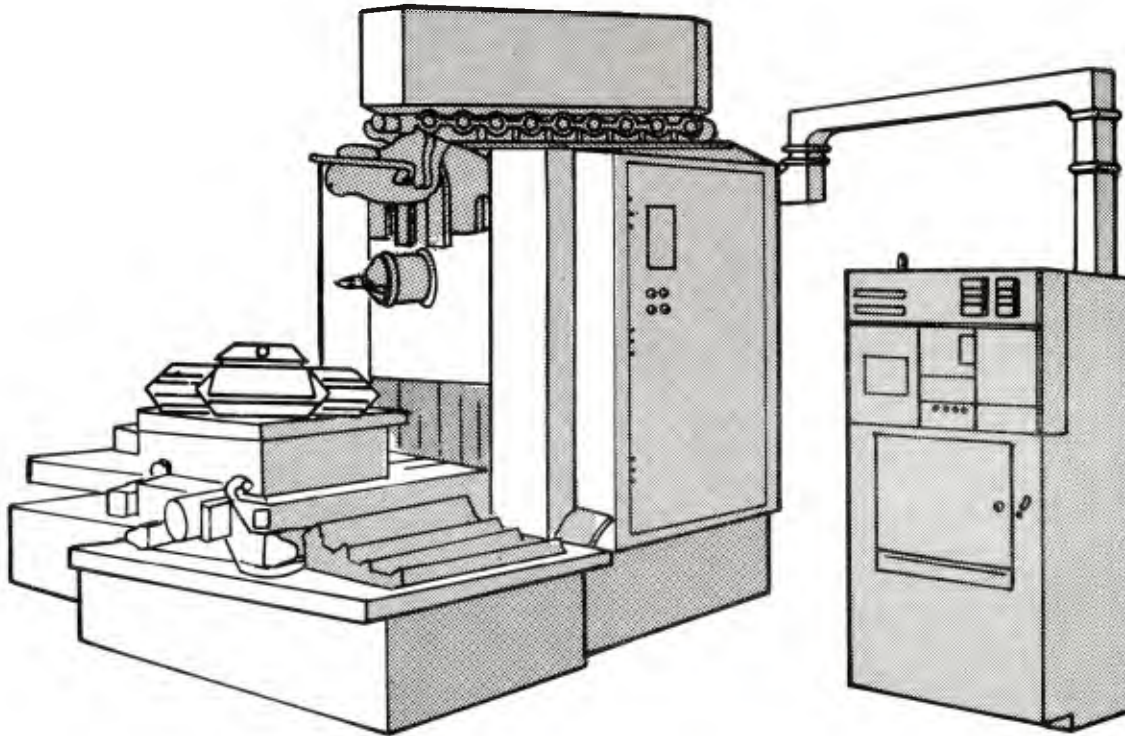


Figure 2

This technology area serves as a focal point for all other technology area activities. Efforts categorized into this area are directed toward increasing the productivity of manufacturing by systematically applying computer technology to all functions which directly and indirectly participate in fabricating parts. The use of Numerical Control (NC) Machine Tools is illustrated as an example of fabrication in Figure 2.

## NUMERICAL CONTROL LANGUAGE EVALUATION

There are several computer languages available on the market to program numerically controlled machine tools. However, there was a need for a document showing objective comparison of the structure and capabilities of these languages.

The US Army Electronics Command sponsored an MMT effort (9679) for the study and documentation of a Numerical Control Language Evaluation. The purpose of this effort was to document comparative information about current systems used in programming NC machine tools, in order that a potential user may use the information to help in making the best choice to meet user requirements.



This effort consisted of two studies. The first study compared seven NC programming languages in order to characterize them qualitatively and quantitatively with respect to their ability to handle milling, drilling, tapping, and boring operations. The languages examined included APT, ADAPT, NUFORM, SPLIT, ACTION, and COMPACT-II. Ten test parts, covering the entire spectrum of complexity from the simplest two-dimensional point-to-point work to complex five axis contoured work, were run using two programs from each language. One of these was programmed by the proponent and the other by a user of each language. The first study results were distributed throughout Government and advertised and made available to industry. Copies may be obtained from the Defense Technical Information Center using Number ADA 004040.

The second study consisted of an effort comparing fifteen NC lathe programming systems characterizing them qualitatively and quantitatively. This effort resulted in a report describing each of the fifteen voluntary participant's systems. The report also describes: the test results of ten parts; the non-technical characteristics of each system, the business and operational characteristics such as hardware and software sources and costs, documentation, training, vendor support and maintenance; a tabulation of the capabilities of the languages for description of the geometrical configurations of the part being programmed; the use of macros to simplify the writing of programs; the success in processing and post processing the program and the verification of the output tape. Copies may be obtained from the Defense Technical Information Center using number ADA 081683.

Additional information about this effort may be obtained by contacting Mr. David Ruppe, Communications Research and Development Command, Autovon 995-4854 or Commercial (617) 923-4854.

## **BLISK AND IMPELLER FABRICATION**

Manufacturing technology was enhanced when the US Army Aviation Research and Development Command (AVRADCOM) completed MMT effort (7103) for the fabrication of the new integral airfoil design for blades and disks (blisks) and single stage impellers, see Figure 3, used in the T700 advanced turboshaft helicopter engine.

The T700-GE-700 turboshaft helicopter engine is the main power plant for the Army in the 1980's and beyond. Production qualified in 1976, conventional, labor intensive methods were originally used to manufacture the blisk and impeller foils. This effort was undertaken to improve the product quality and at the same time reduce the time and cost to manufacture the blisk and impeller. The effort was divided into three task areas: (1) development of prototype production equipment using a NC multi-axis, multi-spindle milling machine; (2) development of finishing procedures to obtain the required airfoil surface finish and contour; and (3) selection of special equipment for inspection of the complete airfoil. The result has been a production manufacturing cell.

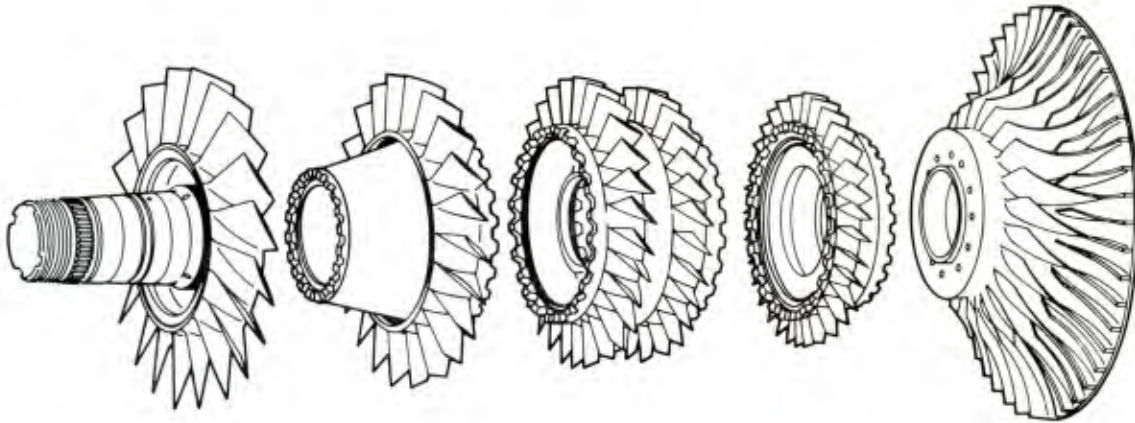


Figure 3

In accomplishing the first task a 4 spindle, 5-axis Computer Numerical Control (CNC) airfoil milling machine was designed and a prototype constructed. This design allowed four blisks to be machined at a time. The machine was to be capable of producing finishes so close to the final specifications that blisks would require no more than a final processing in an automated abrasive flow finishing machine before being ready for use in the T700 engine.

At the initiation of this effort there existed no machine of the type required. Army solicited American machine tool manufacturers for bids on this job. Only one American manufacturer submitted a bid. At the time the Army purchased the American manufactured machine, General Electric spent their own funds to procure a similar Swiss manufactured machine, see Figure 4. The Swiss manufactured machine was concurrently adapted to the required blisk and impeller manufacturing process. The development efforts expended on these machines were crucial to the eventual success of this effort even though the American manufactured machine proved not capable of holding tolerances because of a machine design problem. The Swiss manufactured machine performed the required work quite well.

After the completion of the MMT effort, additional machines were procured for manufacturing blisks and impellers. There are currently six of the 5-axis, 4-spindle NC milling machines in use. The additional machines were implemented at General Electric, Hooksett, New Hampshire under a multi-year facilities project (8169).

The abrasive finishing machine was applied to the finishing operation with excellent results. The abrasive flow machining process prepared the

machined surfaces so that they were able to meet the finished surface requirements. In addition, the leading edge and trailing edge were made into good aerodynamic shapes by the abrasive medium flowing in the same direction as designed airflow over the airfoil.



Figure 4

Equipment and procedures were then developed for the inspection process. The inspection process developed proved to be unusually efficient. Both blisk and impeller airfoils are measured at literally hundreds of points to measure such items as airfoil thickness, chord length, airfoil twist and length, airfoil contours, leading and trailing edge contours, surface roughness and root blend radii.

Manufacturing cost reductions of 60% per engine set lead to a projected program savings of more than \$60 million. In addition to dollar savings, design requirements are more uniformly met resulting in improved engine performance.

Additional information may be obtained by contacting Mr. Fred Reed, AVRADCOM, Autovon 693-1625 or Commercial (314) 263-1625.



## HIGH SPEED DATA COLLECTION AND CONTROL

The US Army Armament Materiel Readiness Command has supported two MMT and seven Facilities efforts\* in recent years to upgrade the small arms ammunition plants. These multiyear efforts have been combined under the Small Caliber Ammunition Modernization Program (SCAMP).

SCAMP was originated to provide a high speed completely integrated and more economical small caliber ammunition production facility. A prototype line was installed first at Twin Cities Army Ammunition Plant.

The final prototype consisted of a production line or module producing at ten times the conventional rate and made up of a series of submodules which manufactured a component or performed a major functional operation. The manufacturing submodules were a series of 24 tool station turret presses with transfer mechanisms between them to transfer the work piece from one operation to the next.

The submodules, individually and together as a system, were operated in a series of preproduction tests from January 1974 thru April 1976 producing over 50,000,000 rounds of 5.56mm ammunition. Lessons learned and improvements developed were incorporated into the five follow-on modules installed and tested at Lake City AAP (LCAAP) from June 1975 to the present.

The Case, Bullet, and Load & Assembly production submodules installed in the building were designed and fabricated by Gulf & Western of Swarthmore, PA. Submodules are monitored and controlled by mini-computer. The computer system controls and monitors the production and ejection of parts-in, parts-out, and ejects by tool stations, and displays this information on the video terminals.

One of the computers keeps track of all cases in the machine, records, and stores data from the inspection devices, and rejects or unloads the cases, classifying them as determined by these inspections. In addition to the inspection function, the computers are used to generate the proper signals and apply them to the self-scan display, and to read the status input programmed by the operator on the control panel, see figure 5.

Performing 100 percent inspection of the product produced by the Case and Load & Assemble Submodules are the Cartridge Case Measurement Eject System (CCMES) and Cartridge Measurement Eject System (CMES) respectively. The CCMES is an automated system for inspection and rejection of cases produced at a rate of 1200 per minute. The Automated Material Handling System was designed to handle production components and materials transported on a first-in first-out basis, between submodules via a Programmable Logic controller (PLC) with manual backup controls in the event of a controller malfunction.

\* Note: Effort numbers are: MMT 6200, 6753; PIF 2396, 2194, 2208, 2146, 2195, 2153, 2205.

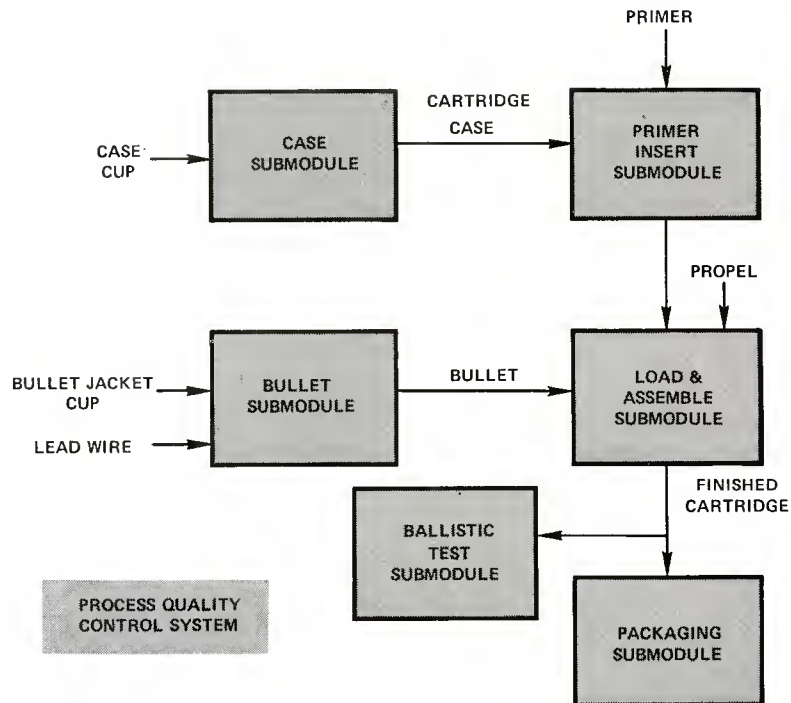


Figure 5

The Management Information System (MIS) is a central data acquisition, data processing, control and communication system that is designed to coordinate data from the production submodules, inspection and material handling systems. If any of the products is unacceptable, MIS will direct the Automated Material Handling System to segregate the bad material from the normal production. Management reports will be provided as requested.

Inventory control information is maintained as well as production and reliability data.

The Ballistic Test Submodule is an integrated production test and data processing system capable of simultaneously testing different calibers of ammunition in several ranges.

Remington Arms Co., the operating contractor at Lake City AAP, produced 63 million rounds of 5.56 ball cartridges on the automated SCAMP equipment in 1979. During the year, productivity on SCAMP was increased 170% and cost was reduced 27%.

Additional information may be obtained by contacting Mr. Brij B. Rai, Munitions Production Base Modernization and Expansion Agency, Autovon 880-4122 or Commercial (201) 328-4122.

## CAM APPLICATIONS FOR THE XM1 TANK

The XM1 Program was initiated in December 1971 when Congress directed the termination of the XM803 Tank System as unnecessarily complex, excessively sophisticated, and too expensive. In 1972 the Army formulated the concept for a new battle tank which was approved by the Deputy Secretary of Defense on 18 January 1973. On 12 November 1976 the Secretary of the Army announced that the Chrysler Corporation competitive prototype concept had been selected to enter Full Scale Engineering Development. Eleven XM1 pilot vehicles with associated hardware were fabricated in the Detroit Arsenal Tank Plant and then tested and evaluated. Concurrently with this activity the Lima Army Tank Plant, at Lima, Ohio, was selected for the initial production site and it was facilitated into the most modern and efficient tank production plant in the Free World through XM1 system funds and facilities project (5025). The Lima Army Tank Plant is currently manufacturing XM1 tanks. Future production plans call for the Detroit Army Tank Plant to join the Lima facility and to manufacture XM1 Tanks in 1982.

The Lima Army Tank Plant has three main CAM applications, these are: the flame cut line, the Hull machining line, and the Turret line. The Hull machining line as an example of a CAM application includes four NC machining stations. The first station mills the side of the Hull for positioning the final drive and torsion bar housing. This work is performed by two traveling column machining centers which are computer controlled with a 24K computer memory. Station two performs a number of drilling and tapping operations for the final drive and torsion bar openings, etc., using two automatic cluster head drilling and tapping machining centers with 24K memory. The third station performs all rough and finish turning operations on the Hull race ring support. A vertical bridge type turning machine with 24K computer storage is used at this station. The fourth station machines the driver's hatch opening, machine fuel inlet, etc. and is depicted in figure 6.

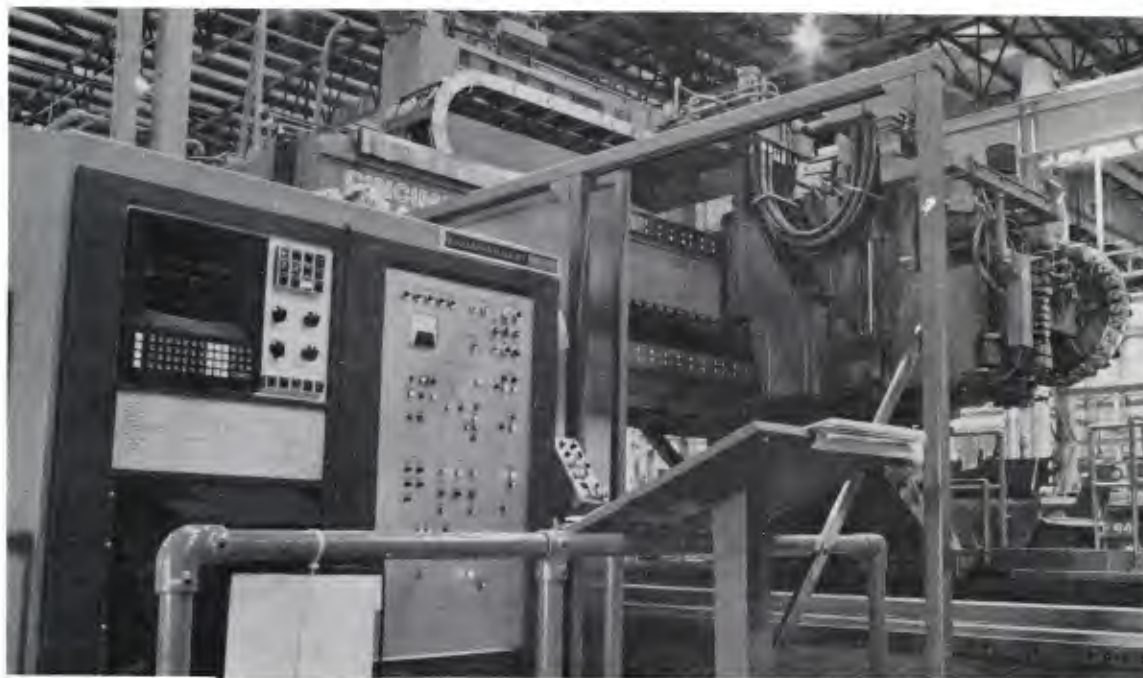


Figure 6



This station utilizes a vertical gantry type machining center with automatic tool changer and 24K computer storage.

The XM1 tank's turbine engine is being manufactured by AVCO Lycoming Division, Stratford, Connecticut. Two examples of new CAM equipment that will be used to manufacture the AGT 1500 gas turbine engine are the laser welding of the recuperator and a computer controlled Flexible Machining System. The Tank-Automotive Command is supporting an MMT effort (5085) which will establish a prototype system for laser welding. The computer controlled laser welding machines produce over 10,000 feet of welds, involved in over 5000 separate passes, required for the production of the recuperator heat exchanger. The complete welding station includes not only the laser machine with the computer and related software to control it, but it also includes work handling equipment to position the parts and the tools so that the required contact between the parts at the weld joint is maintained. The laser machine will increase productivity significantly by welding 250 inches per minute compared to an average of 50 inches per minute using resistance seam welding equipment. The laser welding technique will require less manhours and will also use less utilities than resistance welding.

The Flexible Machining System was procured with XM1 system funds and will be used to economically and expediently machine twelve engine housings. Flexible Machining Systems extend the cost advantages of mass-production transfer line technology to the manufacturing of parts in small to medium size lots. Machine tools, fixtures, tooling and material handling equipment operate under computer control to provide a flexible production system which can handle a variety of parts.

Additional information may be obtained by contacting Major Robert Ramseth, XM1 Program Office, Autovon 273-2480 or Commercial (313) 573-2480.

## **FLEXIBLE MACHINING SYSTEMS**

The US Army Tank-Automotive Command is currently supporting an MMT effort (5082) for the purpose of advancing the application of Flexible Machining System (FMS) technology to combat track vehicle components. Components supported include XM1 turbine engine components, M2 and M3 transmission and turret stabilization components and others.

Machining has been identified as the largest cost driver in Tank manufacture. This effort addresses this area in order to reduce the cost and increase the productivity of machining items in small quantities. This effort established an interface with the MMT program and industry and also established the requirements and data for software system architecture, simulation, and general guide contents.

The first phase of this effort has been coordinated with both user and supplier organizations. Existing FMS equipment is being evaluated and generic criteria and software requirements for an optimized system are being developed. Phase two is continuing to advance programs and software plus drafting a generic guide which will enable potential FMS users to analyze their needs and define an FMS system to satisfy their production requirements.

The XML production facilities at Avco Lycoming for the AGT 1500 gas turbine has a Kearney and Trecker FMS line in a prove out stage. The direct interaction of the 5082 effort with suppliers having or acquiring FMS should result in immediate implementation and payback in the second round of XML facilitization.

Additional information may be obtained by contacting Mr. S. Goodman, TARCOM, Autovon 273-1814/2065 or Commercial (313) 573-1814/2065.

The US Army Armament Materiel Readiness Command supported an MMT effort (7246), which was a comprehensive engineering study to determine areas of possible automation to improve productivity of breech ring manufacturing. This was an effort which resulted in the design of a palletized fixture in which the part was attached, and which could be used with automated material handling equipment providing ease of movement and minimized alignment time at each machine. In addition, the utilization of NC machine tools allowed combining several operations which reduced the number of machining operations performed from 44 to 17. This project was also to be implemented under effort 7246. However, the effort was cancelled after a study determined that the breech ring was not the most economically adaptable configuration for an automated process. Through analysis it was determined that the breech block was a more suitable component part to establish CAM and automation techniques. Due to the breech block's relatively straight lines and box-like shape, it would lend itself to modular type fixturing required for proper handling. Examination of route sheets of three (3) different breech blocks in manufacturing confirmed all were highly adaptable to an automated manufacturing and handling process. Suggested conversion of MM&T funding from 7246 effort to the breech block effort for greater economic benefits, resulted in a trade off to fund another MMT effort (8104), titled "Improved Breech Mechanism Manufacturing." This project is currently being funded to perform the necessary preliminary engineering to design equipment/performance specifications for a proposed Flexible Machining System using a minimum of space and a maximum efficiency in terms of machine tool utilization and reduced handling. The current method of machining a breech block requires 41 machining operations with each operation requiring a general purpose machine and a skilled operator to run the machine. The FMS being studied proposes a reduction in number of operations to approximately 30 and a reduction in the number of operators to one.

Additional information may be obtained by contacting Mr. Alex Wakulenko, Watervliet Arsenal, Autovon 974-5611 or Commercial (518) 266-5611.

## ROTATING BAND WELDING

The US Army Armament Research and Development Command supported an MMT effort (6522) for the application of a microprocessor to control material handling and rotating band welding of Artillery shells. The microprocessor receives input from selected transducers and other sensing devices to provide closed loop control of the entire system. A working prototype was completed under this effort.

A production system was developed and consists of five general parts. These parts include: (1) Heavy operational equipment, (2) Power supply, (3) Gas metal arc welding equipment, (4) Shell coolant system, and (5) Microprocessor. Welded overlay rotating bands are produced by metal deposition while the projectile is turned in a fixture beneath the welding head. See Figure 7.

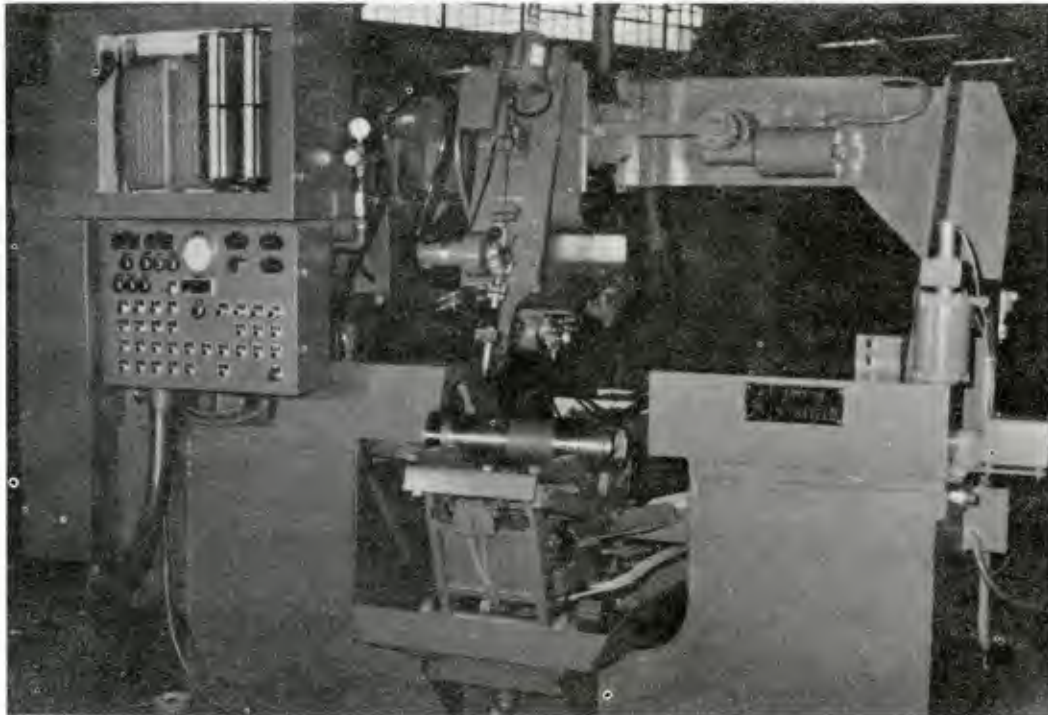


Figure 7

Much of the success of this system is due to the use of a novel linear slope control power supply. The fact that this unit is a solid state, electronic piece of equipment makes possible the successful hookup of power source, television monitor and microprocessor.

The microprocessor controls several interrelated functions in the welding process along with providing monitoring, time and sequence control and management information. The arc length of the welding is monitored by a television camera during operation and feeds information to the microprocessor which controls fluctuation to the power supply. The microprocessor controls or monitors the following functions: weld current, arc voltage, electrode wire feed, auxiliary wire feed, supply of wire, shell rotation speed, torch oscillation frequency, torch amplitude, and shell cooling water flow rate.

The total rotating band welding process was automated under this effort, through the joint applications of a microprocessor, photosensor, television equipment, and a linear slope control power supply. Commands are entered by keyboard while cassettes containing various weld programs for different shell configurations, can be stored and later selected for use when a particular program is needed.

The prototype equipment developed under this MMT effort was installed at Frankford Arsenal in 1975 for use in production and later moved to ARRADCOM, Dover, NJ, where it is being used for R&D type efforts. The concepts developed and demonstrated with the prototype led to the design and purchasing of the following equipment.

<u>FACILITIES</u> <u>PROJECT</u> <u>NUMBER</u>	<u>NUMBER OF</u> <u>MACHINES</u>	<u>LOCATION</u>	<u>AMMUNITION</u> <u>ITEM SUPPORTED</u>
5742974	5	Scranton AAP	M509 8" ICM
5742975	4	New Bedford, MA	M483 155 ICM
5763146	3	Norris, CA	M483 155 ICM
5773508	8	Norris, CA	M509 8" ICM
Not Avail	3	Norris, CA	M549 155 RAP
5772576	9	Louisiana AAP	M483 155 ICM
5773508	4	Waterloo, IA	M329 4.2" Mortar
5793142	18	Mississippi	M483 155 ICM

Benefits received from these efforts include quality improvements from a reduction in rejection rates from the previous 11% rejection, to an approximate 2%. The new equipment requires less skilled operators than the old equipment, thus eliminating extensive training of welding machine operators. Productivity is increased from the old metal deposit rate of 30 pounds of material per hour to approximately 45 pounds of material per hour. It is also anticipated that rates as high as 60 lbs/hr will be achieved on future and some existing equipment. This effort has resulted in savings of over \$1,000,000 at Scranton AAP alone. The point of contact for additional information is Mr. Roger Stanton, ARRADCOM, Autovon 880-5752 or Commercial (201) 328-5752.



## **ELECTRON BEAM FABRICATION OF INTEGRATED CIRCUITS**

Under the US Army Electronics Research and Development Command sponsorship, of MMT effort (9631) the Texas Instrument Company expanded upon its already developed baseline process and equipment. The production equipment was developed under MMT effort (9351) and is used for exposing Electron E-Beam resist directly on a silicon wafer. The laser/computer controlled beam reduced the need for time consuming artwork and masking processes which are the most significant sources of pattern defects during manufacturing and which cause a reduction in yield.

Equivalent manufacturing yield was achieved through the use of automated direct E-Beam technique versus conventional photolithography, using 5 micron design rule, and appropriate resist materials.

Previous E-beam direct writing work has sought to demonstrate improved device performance and packing density capabilities. The object of this program was to develop a manufacturing capability for standard bipolar circuits of conventional design using existing E-beam direct writing equipment. This direct E-beam writing on wafers also enhances fine line (less than one micron) definition and spacing for high speed integration, which was not possible without direct E-beam writing.

This project made available an alternate technique for the volume production of high density, high frequency integrated circuits. The work performed in this effort will support complex fine line semiconductor memories and logic circuits.

The development of an improvement in the E-Beam technology through efforts 9351 and 9631 has resulted from the contribution of over \$17 million of Texas Instrument funds while the Government has contributed seed money of less than 6% or approximately only \$1 million.

The type of circuits applicable are included in the Very High Speed Integrated Circuit (VHSIC) package. Examples are arithmetic logic units, programmable logic arrays, correlators, high speed A-D converter, high speed digital multiplexers and code generators. A design rule below one micron is planned for phase II of the VHSIC program. R&D efforts are in progress to adapt E-beam direct writing techniques to the VHSIC requirements.

Additional information about this effort may be obtained by contacting Mr. William B. Glendinning, ERADCOM, Autovon 995-4396 or Commercial (201) 544-4396.

## **NIGHT VISION**

When widespread acceptance of night vision equipment increased the demand for such units, in the late 1960s and early 1970s, newer, more

productive methods of making the elements used in night vision devices were sought to meet the increased production demands. To accomplish this, several MMT efforts were initiated by the Night Vision Labs. These projects dealt with major elements in night viewing equipment including phosphor screens, photocathodes, inverters, and peripheral components such as power supplies, voltage multiplier circuitry, and housings. CAM applications to this effort played an important roll in making it possible to increase production of the night vision components while maintaining equal or improved quality of the units.

CAM applications dealt with areas of manufacture such as the multi-alkali photocathode processing and improved productivity of the photocathodes elements (MMT effort 9639). After a competitive selection process the photocathodes work was contracted to two companies, the ITT Electro Optics Products Division, Roanoke, VA, and to NI-TEC, Skokie, IL.

ITT developed a computer controlled external process for applying multi-alkali coatings to photocathodes, and NI-TECH developed a computer controlled processing station for the internal application of the coatings. External and internal refer to where the processing is done. External refers to processing the photocathode outside the tube and then transferring it into a vacuum system to the tube. Internal refers to processing the photocathode in position in the tube.

Both companies improved product uniformity and sensitivity through several refinements of their software. One objective was to obtain the sensitivity of the photocathodes at an acceptable 275 microamps per lumen. NI-TEC attained a sensitivity average of 260 microamps per lumen which they felt could generate cathodes of 375 microamps per lumen. ITT increased photocathode sensitivity to 391 microamps per lumen, thus obtaining an increase in output of 40% over specification.

The ITT effort was completed in two phases. The first phase developed a computer controlled automated multialkali photocathode process and the building of test tubes to prove the process. During phase one the automated processing equipment was designed, built, and housed. During the second phase the computer program was further refined for fully automatic photocathode deposition control.

NI-TEC used company funds to incorporate the results of this contract into their production build-up program. They realized a savings of 1.2 hours or approximately \$50 per tube processed. The anticipated savings for the current production schedule is estimated as approximately \$1,250,000 from the 25,000 tubes which will be purchased by the Army, with three producers NITEC, Litton and VARO utilizing techniques and equipment developed through this effort.

Additional information may be obtained from Mr. Sheldon Kramer, Night Vision and Electro Optics Labs, Ft. Belvoir, VA, AV.354-6265 or Commercial (703) 664-6265.



Another effort (9750) supported by ERADCOM developed a computer controlled batch processing machine to reduce the labor and cost involved in producing 18 mm wafer intensifier tubes used in the AN/PVS-5 night vision goggles.

This effort was accomplished in two phases. The first phase was successful and demonstrated the feasibility of batch processing of the 18mm wafer intensifier tubes. Litton Electron Tube Division's existing 5-port design, see Figure 8, was modified to include state-of-the-art techniques including electron gun scrubbing and double idium seal.

In the second phase, Litton designed a 10-port station based upon the results of phase one. This machine was not successful in increasing batch productivity. Its failure was due to a two and one half inch 375° C bakeable valve, the largest available at the time, which severely limited the generated gas load.

Litton incorporated the results of this MMT effort as a basis for their 2nd generation image intensifier production line in 1976, by using multiport processing station. Litton has since built 15 similar computer-controlled 5-port processors. Varian and ITT are developing multiport processing stations for 3rd generation image intensifiers based on the results of this effort.

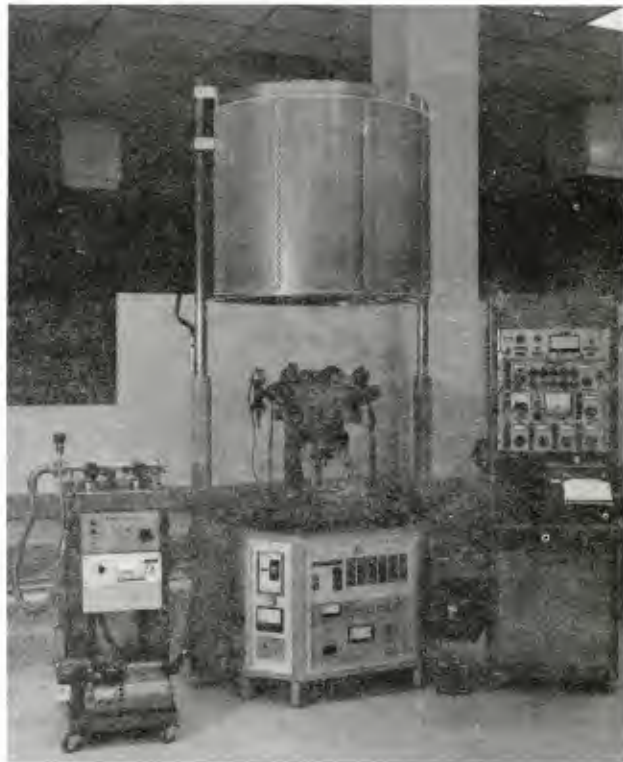


Figure 8

The improved efficiency of the new manufacturing equipment resulted in reduced cost of night-vision goggles. Approximately \$1.7 million in savings is estimated on production contracts for AN/PVS-5 night vision goggles and an additional \$.6 million savings is estimated for future procurements, when compared to single port processing costs.

Additional information may be obtained by contacting Mr. Donald Jenkins, ERADCOM Night Vision and Electro Optics Labs, Ft. Belvoir, VA, Autovon 354-1424 or Commercial (703) 664-1424.

## **300 DATA BASE/DATA AUTOMATION**

Technical Data Automation

Materials Data System

Machine Tool Performance Data Base

## 300 DATA BASE/DATA AUTOMATION

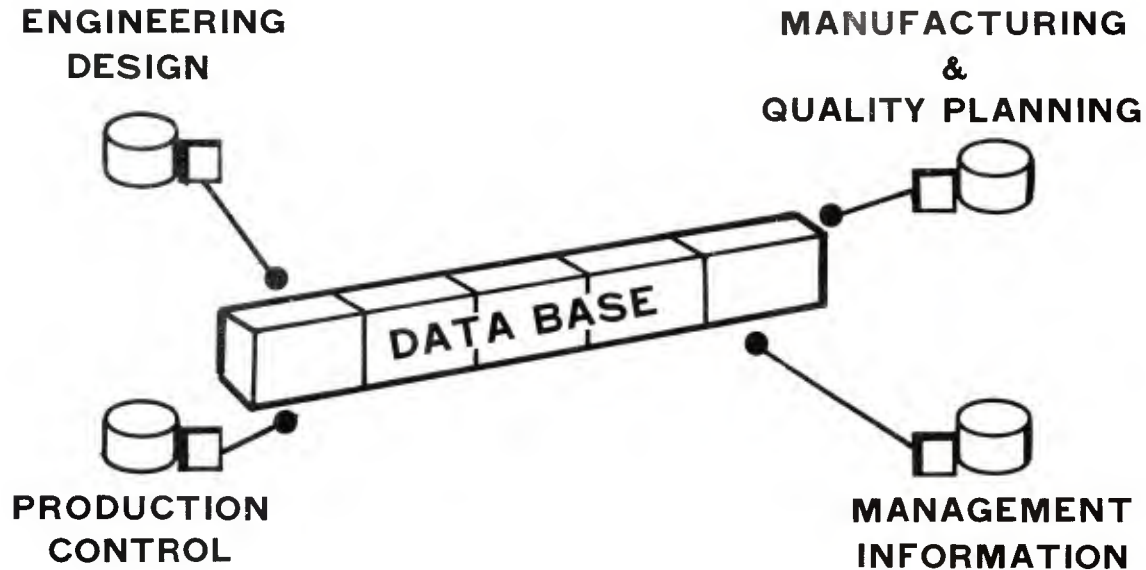


Figure 9

The purpose of Data Base and Data Automation technology is to support the integration of the many stages, subsystems and disciplines of manufacturing into the manufacturing architecture. Although CAM applications may be classified and evaluated in various technology areas, consideration should always be given to their data base/data automation with respect to coordinating and evolving into a common model of manufacturing architecture. The concept of a shared manufacturing data base is illustrated in figure 9.

This is an area in which management is concerned with establishing a network of subsystems which when integrated will provide a total manufacturing information system supportive of planning, production and control.

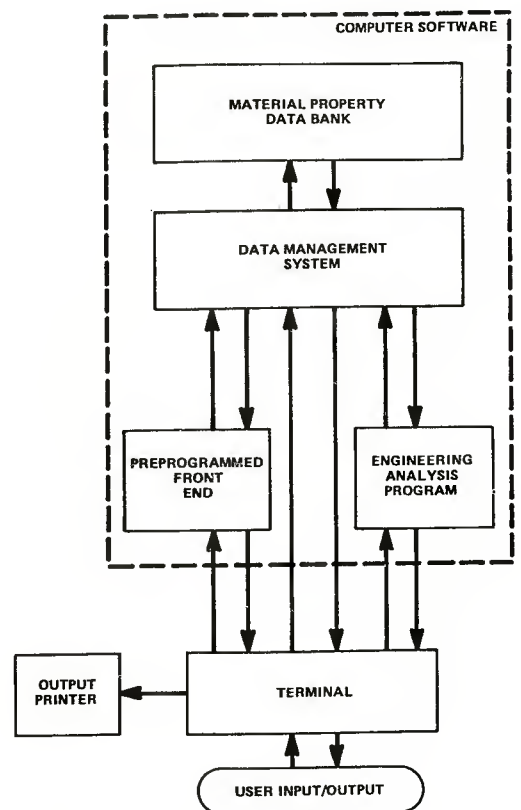
### TECHNICAL DATA AUTOMATION

A current US Army example of the development of a data base for data base automation is the MMT effort (4568) titled, Technical Data/Configuration Management System (TD/CMS) at the US Army Tank-Automotive Command (TACOM). Technical data information generated by Research and Development (R&D) and included in a technical data package (TDP) used in the procurement of end items has typically been developed and processed manually. The manual storage and retrieval along with the updating of changes to specifications and drawings is very time consuming. In addition, the configuration

management and control of all end items is a very time consuming job when done manually. This effort developed TD and CMS programs to establish a standard TD/CMS that could be used DARCOM wide. The benefits from this effort include improved technical data packages, reduction in administrative lead-time for procurement and more effective configuration management. The CMS programs are currently running at Communications and Electronics Readiness Command, Missile Command, and TACOM. ARRADCOM is starting to convert their data base. Instructions have been issued from Materiel Development and Readiness Command (DARCOM) for all subordinate major commands to adopt the standard TD/CMS. Further effort (4568) was continued at TACOM to revise their Automated Microfilm Storage and Retrieval (AMSR) System and develop functional improvements in processing engineering data input to the TACOM Technical Data/Configuration Management System. A follow-on DARCOM Management Information System effort is in progress to develop an aperture card scanner for the Army. This follow-on effort consists of a high speed random access combination raster scan, and laser line follower to read the data. The data is engineering specifications or drawings stored on microfilm aperture cards. The microfilm is scanned, the data is vectorized, and stored in computer memory for later recall. The data is stored in a format suitable for use by a graphics system. Additional information about these efforts may be obtained from Mr. Dale C. Johnson, Autovon 273-1880, or Commercial (313) 573-1880, and Mr. Vernon Pearl, ARRADCOM, Autovon 584-2918 or Commercial (301) 671-2918, respectively.

## MATERIALS DATA SYSTEM

The US Army Armament Research and Development Command (ARRADCOM) completed an MMT effort (4456) in 1979 for a computerized materials property data information system. The objective of this effort was to develop a DARCOM computerized material property data retrieval system to enable remote, on-line access to technical data for polymers (plastics, composites, and rubbers) metals, and ceramics, in support of engineering, manufacturing, and procurement functions. The access modes to typical computerized data are highly dependent on the sophistication of the engineer/user in regard to use/retrieval of design analysis, material technology, and computer technology. In view of this, the system selected provided capability for varied user background. A schematic, Figure 10, illustrates the generalized data retrieval concept utilized in this effort. A data base management system software package, written for IBM computers, was acquired



Schematic, Data Retrieval Concept

Figure 10

and converted compatible with the Army's CDC 6000 series computers. The Data Base Management System is a Data Retrieval System supported by Aeronautical Research Associates of Princeton. Although the total implementation of this effort was not achieved because of curtailment of funds, benefits were achieved by the acquisition of a data base management system structure for material selection and the conversion of the system to the CDC 6000 series computer. Action is being taken to utilize the data management system for other material data projects as funding is made available. An example of using the system is the storing and retrieving information about the chemical resistance of plastics, so that a search may be made indicating which plastic is suitable for use or exposure to chemicals being considered. Additional information may be obtained about this effort by contacting Mr. H. E. Pebly, ARRADCOM, AUTOVON 880-4222 or Commercial (201) 328-4222.

## **MACHINE TOOL PERFORMANCE DATA BASE**

The US Army Armament Material Readiness Command at Rock Island Arsenal has an on-going MMT effort (7802) to establish a data base for machine tool performance specifications. This project when completed will enhance the cost-effective procurement of machine tools with the resultant cost savings in the manufacture of weapons components. This effort will provide machining efficiencies in terms of metal removal rate and costs, along with instrumentation, test and analyses of efficiency in terms of accuracy. The results will be used to efficiently route weapon components according to machine tool performance required, to determine maintenance requirements, and to accurately define performance capability for overhaul, retrofitting, storage, or disposal. Computerized post-processing methods, developed in the first fiscal year effort, were applied in analyzing and comparing machining cycle times of various makes and models of Numerical Control (NC) machines for machining 194 different components of the M198 Howitzer. Workpiece and tool movement spaces were also computed for new models and Rock Island Arsenal's existing models, of machine tools to determine and compare sizes of machines required. Evaluation of NC machine tools is in process and will be coordinated with DIPEC (Defense Industrial Plant Equipment Center). The intent is to establish future overall procurement methodology including the development of new machine tool testing and validation procedures. Computerized data base record keeping of machine tools, malfunctions and maintenance will be developed in the future. Test procedures, type of DBMS techniques and instrumentations will be coordinated with in-house, manufacturers, DIPEC and the International Machine Tool Task Force personnel. Additional information about this effort may be obtained by contacting the project officer, Mr. R. Kirschbaum, AUTOVON 793-5363 or Commercial (309) 794-5363.



## **400 CAD/CAM INTERACTION**

CAD/CAM System Design Manufacturing Interface

Another CAD/CAM System Example

Pattern Fabrication System

CAD/CAM Metal Processing and Die Making

Extrusion of Aluminum, Titanium and Steel

Forging of Track Shoes

Powder Preform Forging

Forming of Metal Shells

Radial Forging

Gear Design and Manufacturing

Improved Foundry Castings

## 400 CAD/CAM INTERACTION

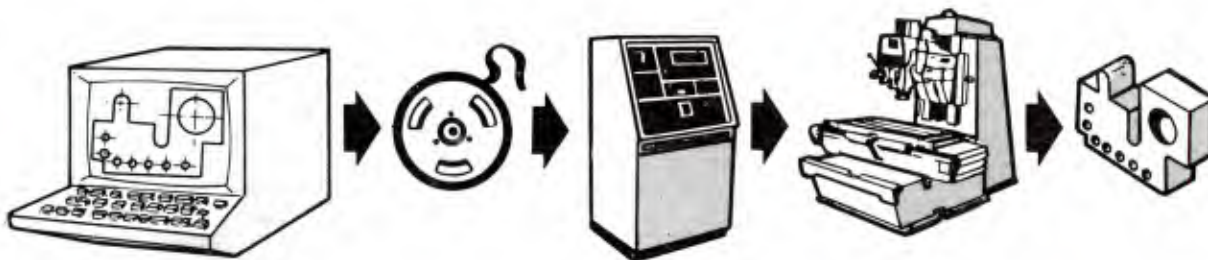


Figure 11

The purpose of this technology area is to establish subsystems and procedures which will integrate the efforts of product design and manufacturing. The underlying concept is that of a common data base between engineering and manufacturing.

In these types of efforts the definition of manufacturing architecture is extended to include the design function, its interaction drivers and computer assisted tools to increase the effectiveness of these interactions. Interactive graphics is one of the computer assisted tools illustrated in Figure 11, which supports a data base for manufacturing. The first three efforts in this section represent installed and operational mini-computer CAD/CAM systems. The remaining efforts represent the status of software development for metal processing and die making.

### CAD/CAM SYSTEM DESIGN MANUFACTURING INTERFACE

An example of CAD/CAM interaction supported through Army MMT effort (7220) is the application and utilization of mini-computers to Direct Numerical Control (DNC) for general purpose machine tools. This effort was completed and became operational in 1975 at Frankford Arsenal.

This effort was established in consonance with the MMT long range plan. Materiel Development and Readiness Command (DARCOM) Numerical Control (NC) working group developed the plan for orderly and judicious expansion of NC technology throughout DARCOM.

Quick response and flexibility in the preparation of NC tapes for part programming was accomplished through the efforts of this project. The system developed was used to prepare NC machine tool tapes for fire control and ammunition components for both production and R&D quantities. The

system was augmented with graphics terminals, interactive computer aided design software, and a high speed plotter. The augmented system was transferred to and has been operational at the US Armament Research and Development Command (ARRADCOM, Dover, NJ) since 1978 for use in support of R&D prototype development, production engineering studies, and related MMT efforts. Figure 12 shows a schematic of the system information flow.

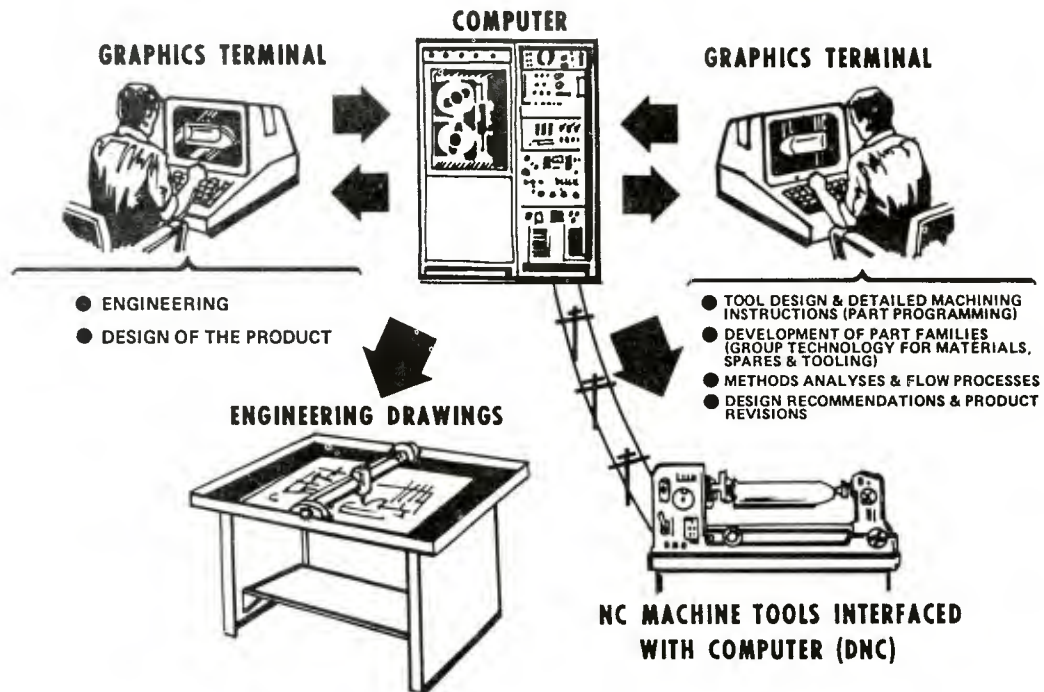


Figure 12

Savings in direct labor manhours were achieved through the reduction in tape preparation time in the first year of operation. An increase in the workload handling capability of the NC machine tools was also achieved.

Additional information on this effort can be obtained from Mr. Stan Hart, ARRADCOM, AV 880-3721 or Commercial (201) 328-3721.

## ANOTHER CAD/CAM SYSTEM EXAMPLE

The US Army Aviation Research and Development Command (AVRADCOM) developed technical data conversion of component dimensions to layout drawings and NC tapes, at Corpus Christi Army Depot (CCAD) under MMT efforts (8125 and 8044). An automatic drafting machine is being successfully used in the preparation of flat pattern layouts and to scribe conventional template stock. The data generated is also used to make NC punch press tapes that are used to manufacture actual production parts.

Engineering drawings are produced for modification kits and repair parts. Performance graphs of jet turbine engines under test have also been produced by the automatic drafting system by using external data input.

An Interactive Graphic Design System is interfaced with the automatic drafting system enabling new designs to be converted into complete detailed drawings with dimension notes. The automatic drafting system will also produce NC tapes for the manufacture of parts and tooling as required by the CCAD workload, see Figure 13.



Figure 13

A significant reduction in manhours has been experienced in design, drafting and NC tape functions since this CAD/CAM system has become operational at CCAD in 1975. Examples where savings in direct manhours have been realized are:

1. Design from sketches using the CRT to prepare drawings for the fixture and gauge to measure turbine blade length for in-process inspection.
2. Design from sketches using the CRT to prepare drawings for the infrared suppressor kit for the COBRA Helicopter. Drawings were suitable as a contractual technical data package.
3. Design from sketches using the CRT to prepare the drawings for work stands, and contour lines.

4. Design from sketches and drawings using the CRT in preparation of NC tapes for components made on NC mills, NC lathes and NC punch. The estimated productivity improvement was 3:1 compared to UNIAPT part programming and 9:1 for manual part programming.

5. Design from drawings using the CRT to prepare detail engineering drawings for panel contour lines.

6. Digitized drawings to generate NC tapes for bulkheads, shelf tops, brackets, plates, and panel assemblies.

7. Digitized components (i.e. skins, plates) to generate NC tape for NC punch.

8. Digitized drawings and components to scribe master templates or scribe components for conventional punch operation.

Improved capabilities have been experienced in the design and manufacture of aircraft parts or tooling such as:

1. Manufacture of emergency needed aircraft replacement parts or tooling when engineering drawings or data are not available.

2. Reduction in lead time.

3. Shorter through put time.

4. Better documentation of manufacturing data.

Point of contact is Mr. Gerald Gorline, AVRADCOM, Autovon 693-1625 or Commercial (314) 263-1625.

## **PATTERN FABRICATION SYSTEM**

The US Army Natick Research and Development Command (NARADCOM) completed an MMT effort (202N) establishing computer aided clothing pattern fabrication techniques in 1976.

Development of clothing patterns has in the past been highly dependent on human skills which reside in "older hands" who are gradually leaving the business. Replacements who could perform these skills were becoming increasingly difficult to find. The application of computer aided technology to pattern making greatly improved NARADCOM's design capability. This effort supports approximately 200 clothing items which require the preparation of approximately 2000 sets of patterns. The system consists of a digital input device, a central processing unit, an interactive video display terminal, alpha-numeric teleprinters and a flat bed plotting or cutting device. The equipment with associated software has the basic capability of digitizing a master pattern with applicable numerical growth data, processing this data and grading the patterns to include all sizes required in a standard military tariff, and plotting or cutting all sizes on standard pattern cardboard. If necessary, style changes and pattern alterations may be made through a telescreen and digital control apparatus.



The system allows for complete standardization of Army clothing patterns by eliminating the persistent problem of individual differences of designer sizing methods.

Benefits obtained included reduction in the cost of pattern fabrication, improved pattern storage and recall operations, established standard pattern designs, and improved quality of Government master patterns.

Additional information may be obtained by contacting Mr. Leonard Campbell, NARADCOM, Autovon 955-2347 or Commercial (617) 653-1000 ext. 2347.

## **CAD/CAM METAL PROCESSING AND DIE MAKING**

Tri-Service efforts are also being expended to improve die designs and manufacturing applications through the development of computer programs in the following areas:

- o Precision forging of steam turbine and jet engine compressor blades.
- o Conventional and precision isothermal forging of aircraft structurals.
- o Forging of hardware for military automotive applications.
- o Extrusion of aluminum shapes (flat face dies).
- o Lubricated extrusion of titanium and steels (smooth entry dies).
- o Rolling of rounds and airfoil shapes.
- o Precision forging of bevel gears.
- o Casting of components for military vehicles.
- o Forging of round hollow components.
- o Forming of sheet metal by brake bending, stretch forming and rubber forming.

Some of these computer programs are ready for immediate use in production, others require updating and improving for practical application, and still others are now being developed. All of these computer programs are available, free of charge, to US companies, after approval of the sponsoring agency.

Under Army sponsorship, Battelle Columbus Laboratories is now investigating the best possible way of putting these programs into wider use by US companies. If government funding is made available it will be possible to improve/modify existing CAD/CAM metal processing software and to develop new urgently needed software. Point of contact is Mr. Roger Gagne, Army Material and Mechanics Research Center (AMMRC), Autovon 955-3436, or Commercial (617) 923-3436.

CAD/CAM efforts for metal processing and die making have been undertaken by the US Army through several MMT efforts. These efforts included: extrusion of aluminum, titanium, and steel; forging of track shoes; powder preform forging; forming of shells; radial forging of rods and tubes; gear design; and casting process.

## EXTRUSION OF ALUMINUM, TITANIUM AND STEEL

AVRADCOM completed an MMT effort (8154) in 1978 on the feasibility of applying CAD/CAM to extrusion of aluminum, titanium and steel structural parts. Although large numbers of extruded aluminum, titanium and steel components are used in the manufacture of military hardware, extrusion technology is still largely based upon empirical cut-and-try methods. This Army effort was directed towards expanding capabilities of the extrusion process and resulted in the development of: (1) CAD/CAM of Streamlined Dies for Lubricated Extrusion of "T" Sections, (2) CAD/CAM of Flat-Faced Dies for Nonlubricated Extrusion of Aluminum Structural Shapes, and (3) Extrusion of "T" Sections of Aluminum, Titanium and Steel using computeraided techniques, see Figure 14.

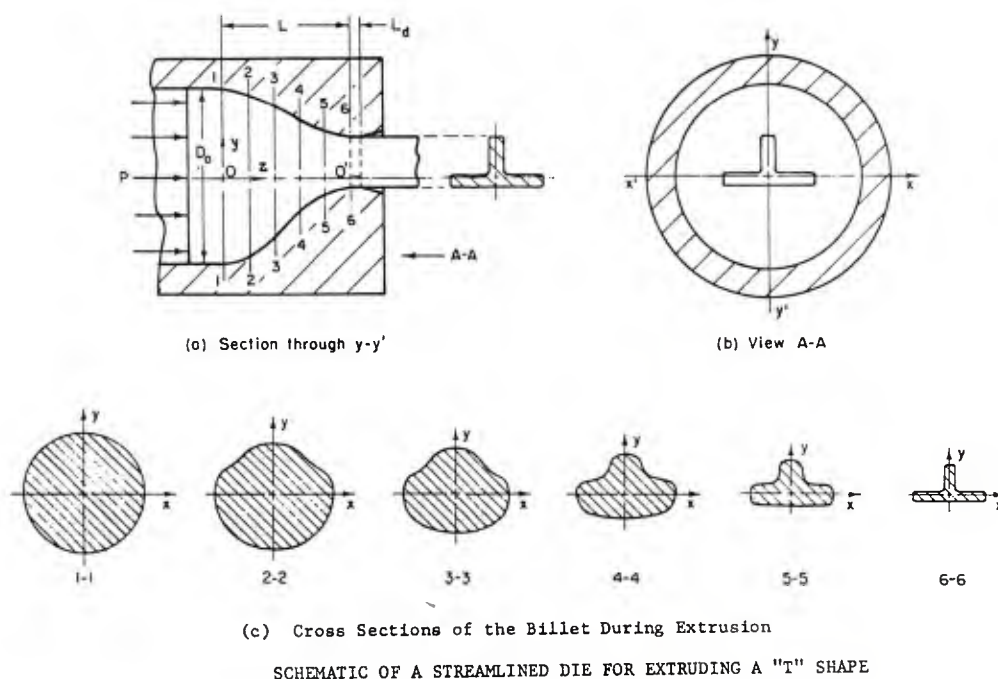


Figure 14

Utilization of this system provides faster design and manufacturing of dies, improved die tolerances, and improved yield via optimum extrusion variables. The Air Force Wright Aeronautical Labs is using this system to design dies and to generate NC tapes for all their aluminum extrusion dies. They report \$10,000 a year savings realized by furnishing copies of the programs to numerous contractors.

A Government/Industry technical briefing was held on 16 June 78 and copies of the final reports have been distributed including copies to a large number of companies who requested copies. There have been a number of papers published about this effort along with reports published in the technical press.

Additional information on this project is available from Mr. Gerald Gorline, AVRADCOM, AV 693-1625 or Commercial (314) 263-1625.

## **FORGING OF TRACK SHOES**

An MMT effort (4561) for Computer Aided Die Design and Computer Aided Manufacturing of Forging of Track Shoes and Links was completed in January 1977 by US Army Tank-Automotive Command (TACOM). A computerized system for designing and manufacturing Army vehicle track shoe dies was completed under this project. The computerized system is known as TRACKS, and is a totally interactive system that greatly assists die designers. The designer begins the die design process by feeding the computer a file of coordinates describing each cross section of the forging. With this information, the computer then calculates the geometric properties of each section and performs stress analysis calculating and displaying stress distribution curves and metal flow surfaces.

When the designer is satisfied with the load analysis and preform design for all sections, the CAM phase of TRACKS is used to prepare a tape for NC machining of a model or an EDM electrode of the preform.

The TRACK system of computer programs is very flexible and can be applied to other forgings. For example forgings with axisymmetric cross sections, and radial metal flow with flash on one side or on both sides can be designed. The TRACK system is available to any interested US company. A final report and a 12 minute 16 mm film has been produced and disseminated to the forging industry where this program has been well accepted.

For additional information contact Mr. Tom Wassel, TACOM, AV 273-1814 or Commercial (313) 573-1814.

## **POWDER PREFORM FORGING**

The US Army Armament Material Readiness Command (ARRCOM), at Rock Island Arsenal, has been supporting an MMT effort (7649) to computerize powder metallurgy forging design. The objective of this effort was to use CAM techniques to minimize the costs associated with development of the powder metallurgy forging process for the manufacture of weapons components. Equipment, dies and tooling were constructed; experimental specimens were fabricated; and experimental and analytical techniques were refined for workability testing and experimental modeling of flow and fracture. An interactive graphics

computer program was developed to calculate pressure and density distributions for simple shapes under plane strain and axisymmetric strain. A graphics program was also developed to give pressure and density distributions and specimen shapes at various stages of forging for different forging directions. An improved APT (Automatically Programmed Tools) program called APT2D was developed which is capable of describing complex 3-dimensional geometrics. The emphasis on this program is on simplicity of use rather than on sophistication.

Computer graphics have been used to design the preform for the M-85 guide cartridge ramp. Planned efforts include the fabrication of the compaction and forging dies for the guide cartridge ramp. Also the component and a test specimen will be forged and evaluated.

Additional information may be obtained by contacting Mr. R. Kalkan, Rock Island Arsenal, Autovon 793-5504 or Commercial (309) 794-5504.

## **FORMING OF METAL SHELLS**

ARRADCOM sponsored an MMT effort (6716) for the computer aided mathematical modeling of forming operations for current and future artillery metal parts designs.

In the early 1970's there was a recognized need for coordination between artillery metal parts manufacturers and designers. This need resulted in the development of computer software programs for cold/hot nosing operations and for cold/hot drawing operations, along with continued work in the development of nosing, piercing, cabbaging and blocking operations.

The programs developed for metal nosing and drawing provide a diagnostic tool which predicts the optimum combination of process variables for defect free nosing and drawing of shells. Predictions are made for vital requirements such as the wall thickness, elongation, and buckling of the shell along with load-stroke curve indicating the number of strokes and stroke pressure required by the press. The computer program "NOSING" was loaded into the ARRADCOM computer system. A report was published for the nosing effort in June 1978, with a technical paper entitled "Computer-aided Simulation of Hot and Cold Nosing of Shells" presented at the Seventh North American Metal-working Research Conference held on 15 May 1979.

The computer program, see Figure 15, for "DRAWING" was also loaded into the ARRADCOM computer system. A final report was published in May 1979, with a technical paper entitled, "Application of Process Modeling to Shell Drawing Operations Under Actual Production Conditions" presented at the Annual Manufacturing Technology Advisory Group Conference 22-25 October 1979. Work is nearing completion on the mathematical modeling and confirmation testing of the piercing, cabbaging and blocking operation.





MATERIAL: STEEL 1045 NO. OF SIMULATION STEPS: 67  
 RAM SPEED: 80. INCH/MIN DRAWING TEMPERATURE: 2000.00 F

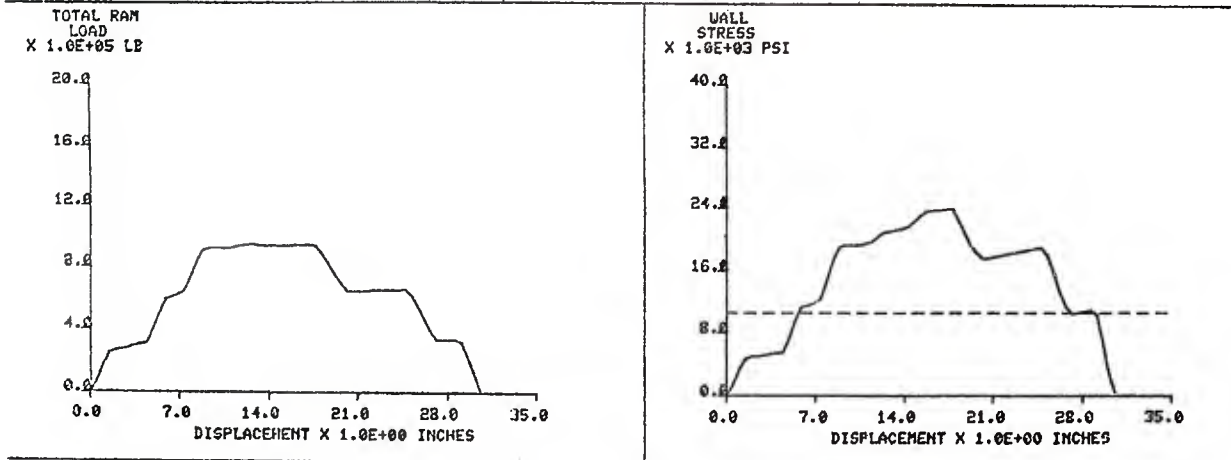


Figure 15

Cost savings are derived from a reduction in time required to prepare technical data packages for equipment procurement. Set-up time is reduced which also improves readiness for production. Through more accurate product and machining data predictions, energy savings will result from less power consumption needs for forming, less scrapped parts, and through improved tool life.

Additional information about this effort may be obtained by contacting Mr. Fee M. Lee, ARRADCOM, Autovon 880-4462 or Commercial (201) 328-4462.

## RADIAL FORGING

Radial forging is a process which reduces the diameter of metal ingots and bars to form precision round or tubular components through the application of a large number of high speed hammer strokes by dies arranged radially around the work piece. The US Army has applied radial forging successfully to the manufacture of large cannon tubes. The quality of the forged cannon tube is significantly influenced by the design of the radial forging dies used in the manufacturing process.

ARRCOM, at Watervliet Arsenal, supported an MMT effort (6943) for analysis and optimization of the radial forging process for manufacturing gun barrels. A second effort (7588) subtask was also supported for rotary forge integrated production technology.



These efforts, 6943 and 7588 subtask, developed computer software programs for optimizing the radial forging process for manufacturing cannon barrels. These software programs provide analysis information for the design of the forging die while also predicting reliable flow stress and friction data of the deforming metal under cold and hot working conditions.

Additional information may be obtained by contacting Mr. L. Liuzzi, Watervliet Arsenal, Autovon 974-5827 or Commercial (518) 266-4610, ext. 5719.

## **GEAR DIE DESIGN AND MANUFACTURING**

TACOM is currently sponsoring an MMT effort (5024) to apply computer aided manufacturing technology to gear design and manufacture.

Gear manufacturing processes are highly specialized due to the complex geometry and high accuracy requirements of the teeth. Some gears, such as bevel gears, are so complex that they cannot be completely illustrated in a two plane drawing. Since the three dimensional visualization of these gears cannot be displayed in two dimensional drawings, the bevel gears are defined dimensionally, but are presented in terms of requirements for their tooth bearing patterns. Under the present method, the proper tooth bearing patterns are then made by trial and error methods. The accuracy of the finished gear is directly affected by the accuracy of the gear blank. Considerable scrap losses, unexpected die wear and breakage, and the cost of forging dies represent a sizable portion of the manufacturing costs for these high performance gears.

The current effort has as its objectives to develop CAD techniques for the design of preforming and finishing dies for both the precision forging and powder metallurgy operations, along with developing CAM methods for machining the forging dies.

Currently a set of computer programs has been developed to define the exact tooth form for hypoid or spiral bevel gear or pinion. The major portions of the stress and temperature analyses have been programmed. Computer programs are also being developed for the elastic analysis of the die and for determining temperature distribution in both the gear tooth and the die.

The CAD techniques, when completed will transform dimensional data from engineering drawings of bevel gears into a die design considering such parameters as flash volume, forging load and surface finish. Dies will then be produced by CAM techniques such as NC machining or electronic discharge machining. The CAD/CAM system, when completed, will reduce die manufacturing costs and scrap losses in gear production.

Additional information may be obtained by contacting Mr. T. Wassel, TACOM, Autovon 273-2065 or Commercial (313) 573-2065.

## IMPROVED FOUNDRY CASTINGS

TACOM is sponsoring an MMT effort (5014) to improve foundry casting processes utilizing computer aided flow and thermal analysis. The casting process is an optimum method for producing complex shapes in many alloys. The casting process requires lower capital investment cost in equipment and lower cost of raw materials than most other metal processes. However, the casting process is wasteful in the use of raw materials and energy. Approximately 50% more material is melted than utilized in the final cast configuration. These inefficiencies of energy, scrap, and waste material provide areas for potential improvement. The objective of this on-going effort is the optimization of fluid flow and thermal analysis of molten metals as affected by mold and pattern design through simulation of the casting process. The interactive graphics system will allow the locating/relocating and sizing of gates and risers in castings and simulate the filling process so that defects (e.g., shrinkage) can be avoided and scrap can be reduced. Thermal analysis will be used with computer graphics to simulate the mold filling process. The pattern shape will be adjusted with an interactive graphics terminal to effect design optimization. The pattern will then be generated by NC machining, yielding a CAM foundry process.

Additional information may be obtained by contacting Mr. T. Wassel, TACOM, Autovon 273-2065 or Commercial (313) 573-2065.

## **500 PLANNING AND GROUP TECHNOLOGY**

Group Technology

Computerized Process Planning

## 500 PLANNING AND GROUP TECHNOLOGY

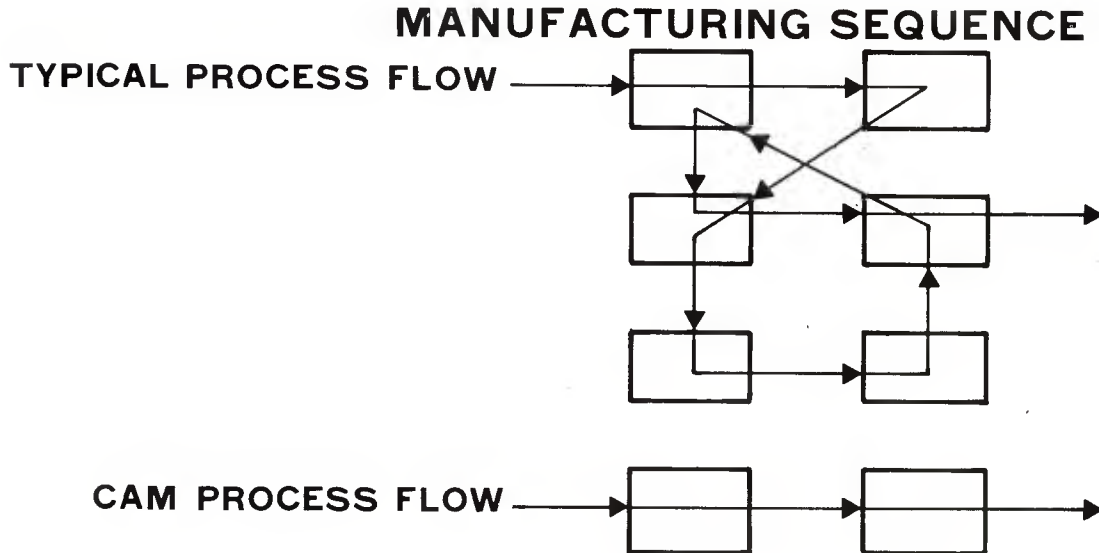


Figure 16

This area encompasses efforts directed at optimizing process planning, production scheduling and control, factory layout and other tasks that have a significant impact on manufacturing cost and which are normally performed by indirect personnel. An example of improved factory layout is illustrated in Figure 16.

### GROUP TECHNOLOGY

Group Technology (GT) is a manufacturing philosophy that uses a parts classification coding system designed to apply the economics of mass production to batch release manufacturing. GT uses the approach of grouping and identifying parts by their common design and manufacturing characteristics. Parts identified as similar and requiring the same tooling are scheduled together through the entire manufacturing process, thus reducing the set-up times and work in process time, see Figure 17.

Anticipated part work loads are analyzed for manufacturing machine tool requirements. These machine tool requirements are placed into manufacturing cells to help expedite part processing. The GT approach of modernizing small batch manufacturing of similar parts into families provides simplicity and efficiency of manufacture, helps to simplify planning procedures, eliminates duplications of parts, reduces the number of duplicate dies and fixtures in use and reduces in-process inventory.



Figure 17

MICLASS (Metal Institute Classification System) is the name of a GT coding and classification system. The rights to use this System were purchased by the US Army from OIR Inc. (Organization for Industrial Research), as a result of a study initiated at Frankford Arsenal in 1974 under the completed MMT effort number 7430.\* GT Software responsibility was later transferred to ARRADCOM where it is available for Army wide usage. The point of contact for information on acquiring this system is Mr. Stan Hart, ARRADCOM, AV 880-3721, or Commercial (201) 328-3721.

In the effort 7430 GT was applied to glass and metal fire control components. MICLASS was used to code each of 1100 fire control part drawings which were then used in a series of MICLASS computer analysis programs to test the feasibility of using this type of system for planning purposes. The results proved successful. The success of this feasibility study lead to three follow-on MMT efforts at ARRADCOM and ARRCOM, which are implementing group technology into the weapons environment. Currently GT is being applied to MMT efforts at Watervliet Arsenal (7724), at Rock Island Arsenal (7949 along with PIF 8129 when funded), and at ARRADCOM (7963). Rock Island Arsenal and Watervliet Arsenal have both acquired the GT MICLASS package and are in the process of implementing it to institute a classification system which will eliminate design duplications, reduce number of parts in the manufacturing system and eventually develop the technique of cell, part-family manufacture. The implementation of the GT effort at RIA is considered a pacing effort to a planned modernization project (PIF 8129) at RIA. The GT software is being used to evaluate the manufacturing requirements and as an aid in the machine tool analysis and replacement studies.

ARRADCOM (7963) has installed an improved MICLASS version 2.0 which provides expanded capability and a more flexible record layout. ARRADCOM is in the process of acquiring a MIPLAN system from OIR Inc. This system is a production oriented computer assisted process planning software package. Process plans can be generated in any of three ways: (1) construct a new process plan from standard data for each operation; (2) retrieve a previously used process plan from the files by part number or other descriptor; or (3) use partial or complete group technology code numbers to retrieve plans for the same or similar parts. Retrieved plans may be edited to meet specific requirements.

\* Additional information on MMT efforts using Group Technology is listed in Appendix A under thrust area 500 Planning and Group Technology.



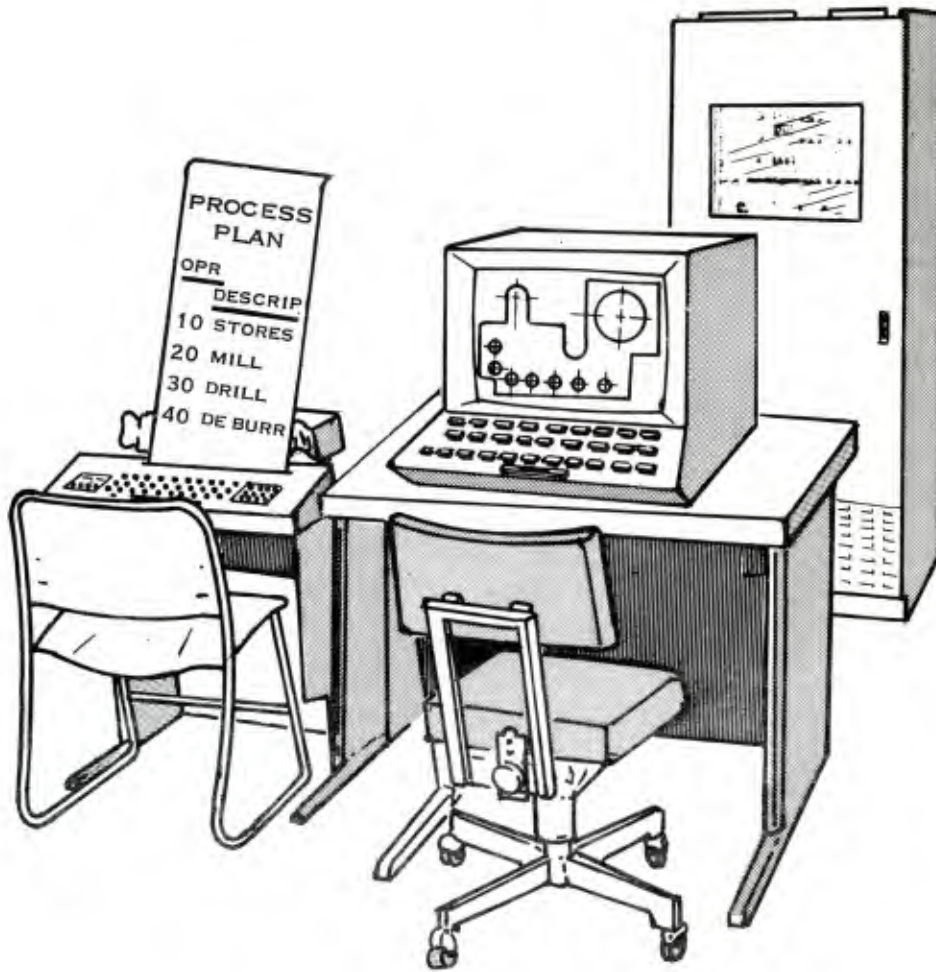


Figure 18

## COMPUTERIZED PROCESS PLANNING

Computerized Process Planning (CPP) is typically described as either a variant type or a generative type, see Figure 18. The variant type CPP is based on the approach of storing and retrieving standard process plans for a family of parts. Using coding and classification techniques, process plans are retrieved, and if necessary, modified for a new part. The generative type of CPP relies on the computer to make process decisions. Based upon a description (Geometric Model) of the part, the system produces a process plan using optimization routines. The OIR MIPLAN system is in principle a variant type CPP system, with some computer assist in the generation of process plans.

Computerized Production Process Planning (CPPP) for cylindrical machined parts was accomplished through an MMT effort (3232) by the US Army Missile

Command (MICOM). This CPPP includes both variant and generative characteristics and is designed to be independent of the production methods or machining processes of a particular manufacturer. Rather than building a particular manufacturing technology into the computer system, process decisions modeling is used to express the manufacturing rationale for fabricating a family of parts. This approach allows each workshop to program its own resources. The rules are written in an English-like problem oriented language which are converted into a coded form by a special language processor. The coded rules are then stored in the data base and used by the computer during process planning.

There are two types of process rules utilized in this CPPP system. The first are the process decisions rules, which are programmed to generate a sequence of operations, and the second are the tool selection rules. Process plans are generated, using programmed manufacturing intelligence, from a description of the part design and raw material. The system will produce a sequence of operations and then determine detailed operation plans by selecting the best combination of machine tools and cutting information. A dimensioned sketch is produced of the workpiece identifying the cuts to be made. The system is also designed to output standard production procedures for nonmetal cutting operations. This successfully demonstrated computerized production process planning system is currently limited in its application to a small range of part geometries. The present CPPP software does not provide fully automated process planning for all parts in all workshops. Fully automated process planning in all workshops is still many years away.

A follow-on effort (1021) is currently being undertaken by MICOM to increase the range of machined cylindrical part geometries covered by CPPP. This effort will also develop a conversational, interactive, graphic capability for input of part design and raw material data, along with a number of other improvements to the program. The general goals of the follow-on effort are to develop an operational CPPP capability and initiate transfer of the technology to industry.

Additional information may be obtained by contacting Mr. Richard Kotler, MICOM, Autovon 746-2065 or Commercial (205) 876-2065.

## **600 MANUFACTURING CONTROL**

### **Factory Management Control Systems**

## 600 MANUFACTURING CONTROL

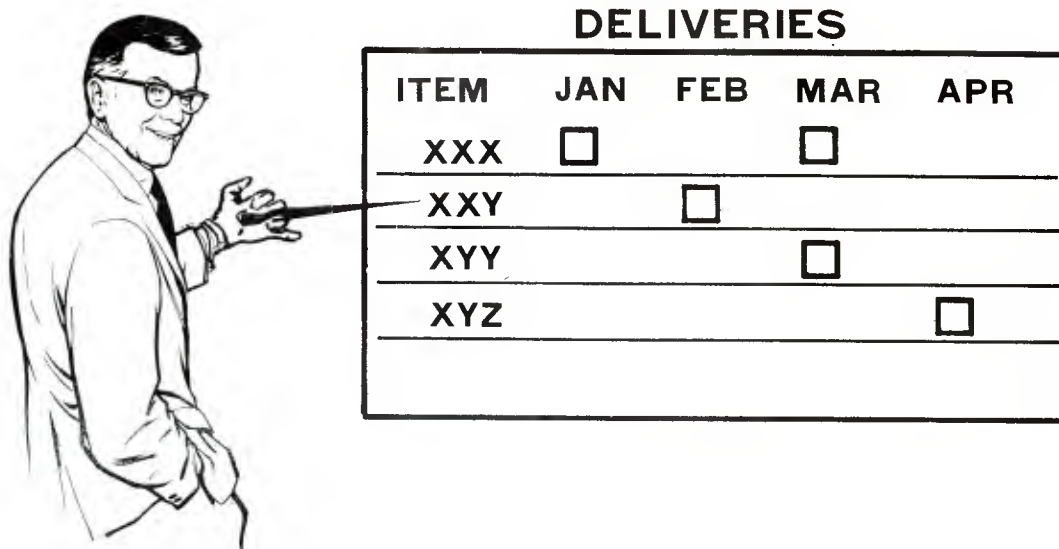


Figure 19

The generic technology for producing management oriented information tools for scheduling, monitoring and controlling operations within the manufacturing environment is addressed by efforts in this technology area. It is closely related to the technology areas of Fabrication, and Planning and Group Technology. An example of a scheduling tool is a gantt chart as shown in Figure 19. Production manufacturing control activities historically bear the major burden for exercising the coordination of production facilities to produce products on schedule at an optimum cost. Manual systems of scheduling, monitoring and controlling processes are not sufficiently responsive to a constantly changing workload environment to permit optimization of high productivity and economics offered by modern manufacturing methods and equipment. The US Army has on-going or completed several MMT projects oriented towards applying computers to assist, on a timely basis, manufacturing processes, techniques and equipment for optimizing production of Army materiel. Two major efforts in factory management control systems were undertaken at Watervliet Arsenal and Rock Island Arsenal.

### FACTORY MANAGEMENT CONTROL SYSTEMS

Improved manufacturing control through data automation was accomplished by ARRCOM at Watervliet Arsenal (WVT) under a related MMT effort (7248) to a modernization effort (8015). The three year MMT effort was completed in July 1979.

Production Automated Control System (PACS) was implemented and resulted in integrating automation into the production planning and control area and to some degree into the financial management area.

WVT implemented an automated Shop Data Collection (SDC) system whose labor reporting portion drives the entire Production and Financial Management system. There is future anticipated growth in the use of the SDC systems in such activities as Quality Control, Maintenance and Repair, Inventory Control, etc.

Workload forecasting simulation, an on-line system, permits master scheduling activities to simulate new workloads, schedule and evaluate their impacts on labor, prior to acceptance of new manufacturing orders. This system integrated with SDC labor reporting is up dated daily permitting forecasting systems to consider work completed to date on firm orders, thus permitting more accurate projection and simulation of schedules and workload.

A Production Planning and Control Data Base System was also developed and installed at WVT. Basic software incorporates the use of IBM's Chain File Management System, which allows maintenance of manufacturing Bills of Material (BOM) and incorporates procurement specifications. BOM can be exploded determining part requirements while simultaneously accessing the process planning data base, computing manufacturing cost estimates and generating purchase requests complete with production materials specifications. Through the implementation of PACS, feedback of data to shop managers is furnished at 0730 hours each day, reflecting the previous day's progress, problems and performance. By receipt of accurate and timely information, shop supervision is more responsive to problem solving. Shop net efficiency one year prior to the start of this effort reflected 88.3%, and in 1979 shop efficiencies reflected 92.2%, an increase over the base year of 3.9%, which equates to 30 productive direct labor personnel. It should be noted that conservatively only 1%, not the whole 3.9%, is estimated to be attributed to the PACS effort. Additional hard savings (thru attrition) were realized by the reduction of eight time control personnel.

A Pilot Automated Shop Loading and Control System (PASLACS) is being implemented at Rock Island Arsenal (RIA) under an MMT effort (7580). This system consists of four modules, (1) the Master Schedule and Planning Module, (2) the Inventory/Open Order Module, (3) the Cost Monitoring and Control Module, and (4) the Materials Requirements and Capacity Planning Module. The first two Modules have been implemented while the Materials Requirements and Capacity Planning Module is in the final completion stage, as is the Cost Monitoring and Control Module.

The Master Schedule and Planning (MSP) Module maintains status file of customer orders, inventory and manufacturing orders. This module also processes purchase orders, generates inventory status reports, processes manufacturing orders and generates a daily dispatching report.



The Cost Monitoring and Control Module will maintain cost records, generate manufacturing cost reports on a daily, weekly and monthly basis, develop unit cost for estimating purposes and allocate manufacturing cost to customer orders.

The Materials Requirement and Capacity Planning Module will determine material requirements, suggest make or purchase orders, generate capacity requirements reports, and generate capacity control (input/output) reports.

The completed installation of PASLACS will provide management with the visibility and control required in a job shop environment to produce benefits such as:

1. Improved ability to assess the impact of new workload, revised delivery requirements, and revised priorities.
2. Improved delivery performance through early identification of bottlenecks allowing their early resolution.
3. Accurate workload modeling which will result in cost effective allocation of resources.

RIA is currently pursuing another facilities effort (6966) for factory automated communication systems (FACS). This effort will accomplish three functions: The first function will be data capture and file inquiry, the second will be the shop floor control file and maintenance, and the third function will consist of manufacturing planning.

This effort (6966) will replace the present outdated and fast failing data collection system which was installed in 1967. The new data collection system will provide data input and output in manufacturing areas, inspection cribs, in-process store cribs, and selected office areas. The new FACS will be capable of reducing wait time in releasing new job orders through the use of CRT image transmissions originated in selected areas. Information retrieved will also reduce wait times for other facets of factory source data management. Information will be transmitted once a day, from the data collected from the new terminals, to update the host IBM 360 computer. The host computer will be down loaded once a day so that information available at terminals will represent prior performance of up to 24 hours old. The Arsenal Operations Directorate will also separately request to expand the host IBM 360 computer with an IBM 4341 to upgrade FACS functions capabilities. Additional information may be obtained by contacting Mr. S. C. Macomber, RIA, Autovon 793-6316 or Commercial (309) 794-6316.

MICOM has a Manufacturing Control System MMT effort (3268) for developing an automatic control for plating printed wire boards (PWB). Plating baths used for PWB have an extremely large number of variables which influence PWB quality. Variables include plating voltages, current densities, time in solutions, solution Ph, solution composition, and cleaning and rinsing time between baths. The degree of complexity is such that manual control methods can not maintain tight tolerances that are required for a

high quality PWB. If any variable drifts out of relatively narrow bounds, impaired quality results. This MMT effort resulted in the selection of an analytical sensing subsystem which uses a computerized polarographic analyzer for the simultaneous determination of two or more constituents in each processing solution. Also, specific analytical control procedures have been developed for each of the processing solutions in a typical PWB plating line. Equipment has been acquired, and testing of solutions and implementation of an inventory control system have begun. An automatic sensing and control system is being assembled and will be tested on a small automatic PWB plating line before being installed in a production PWB plating line. Additional information on this effort may be obtained by contacting Mr. Loyd L. Woodham, MICOM, AV 746-1572 or Commercial (205) 876-1572.

## **700 ASSEMBLY**

Computer Controlled Fabrication and Packaging

## 700 ASSEMBLY



Figure 20

The integration of computer aided technology into assembly operations, is illustrated by the use of robotics in assembly of printed circuit boards, as shown in Figure 20. Factors typically considered in assembly range from aids for planning, simulation and design to totally automatic machines which perform assembly. The increased use of robots in assembly introduces the need for improved programming languages, hierarcial control, end effectors and tools, sensing systems and machine intelligence.

## COMPUTER CONTROLLED FABRICATION AND PACKAGING

The US Army Armament Research and Development Command (ARRADCOM) has supported an MMT effort (4105) which supports automated increment loading and assembly of propelling charges with central core igniters. This multi-year MMT effort is for support of Initial Production Facility (IPF) effort (0012) at Crane Army Ammunition Activity (CAAA), Indiana and another facility effort (2694) at Indiana Army Ammunition Plant IAAP to provide automated equipment and installation technical support. The purpose of this effort

was to automate the load, assemble and pack (LAP) operations by providing new equipment and design techniques of current state-of-the-art compatible with the modernization trend. The developed prototype equipment is being installed at the CAAA. At present, the loader and assembler are installed at CAAA ready for live loading and prove-out testing.

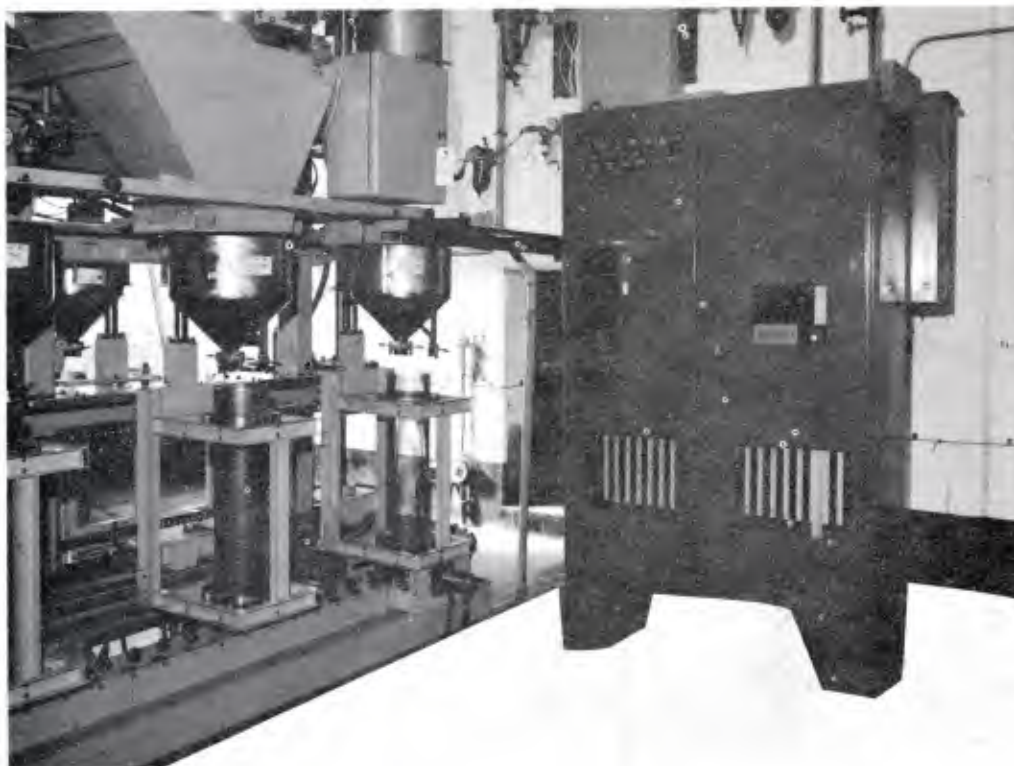


Figure 21

This MMT effort (4105) represents one of the first Army applications using programmable controllers for process manipulation, see Figure 21. A controller is used on the load module working in conjunction with the scale system to provide accurate weight of the propellant charges loaded into the bags. In addition, the programmable controller is used to control the duration of the vibration cycle, provide component weight traceability and determine acceptability of the final loaded increment. A programmable controller is also applied to the fabrication of the assembly module which requires the same type traceability and monitoring as before, along with various timing functions. The packout systems also use a programmable controller to monitor in-process rejects and controls subsequent functions thereby insuring that work is not performed on rejected charges. A totally integrated computer control system has been designed for the expansion project at IAAP. The follow on expansion effort (2694) at IAAP is in-process.

Additional information about these efforts may be obtained by contacting Mr. C. J. Carnali, ARRADCOM, Autovon 880-4162 or Commercial (201) 328-4162.



# **800 SIMULATION, MODELING & OPERATIONS RESEARCH**

## **Simulation of Production Line**

## 800 SIMULATION, MODELING & OPERATIONS RESEARCH

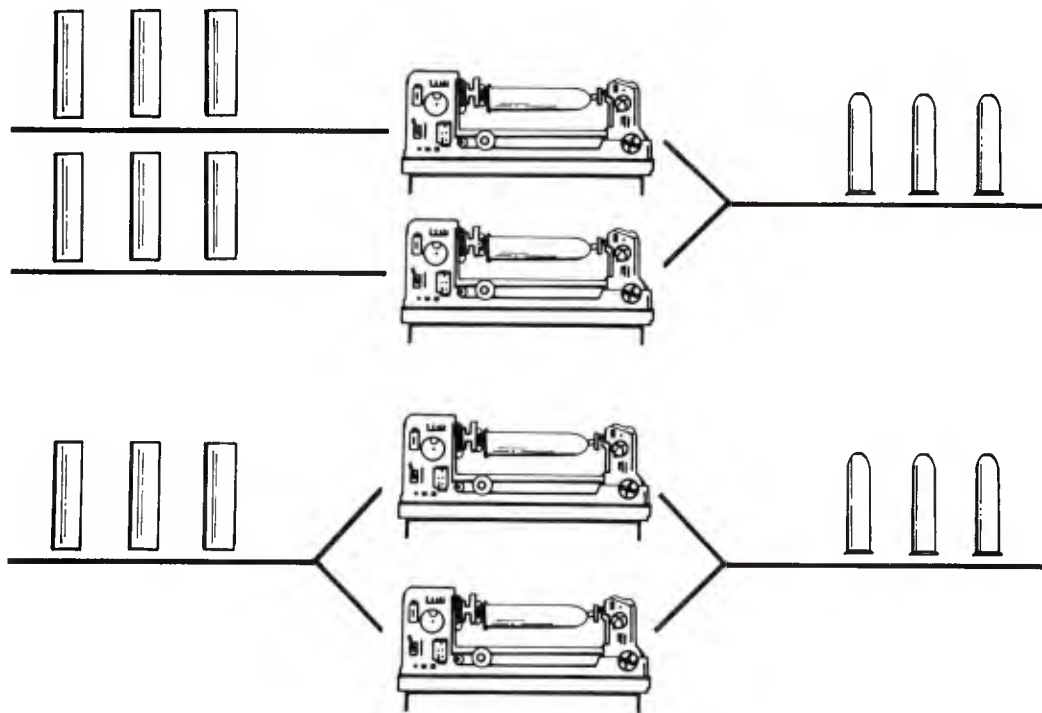


Figure 22

The soft technology for optimizing manufacturing systems through the application of operations research techniques. The modeling of one manufacturing operation is illustrated in Figure 22. An analysis of the reliability of machine tools and handling equipment would be included in an evaluation of an operation.

### SIMULATION OF PRODUCTION LINE

The US Army Armament Research and Development Command (ARRADCOM) is currently supporting an MMT effort (6682) for the simulation of ammunition production lines. The purpose of this effort is to develop a computer simulation (model) which will be used as an aid in the system design of modernized and/or new metal parts (MPTS) production lines. The computer model will be used to simulate the production process, taking into account machine failures and availabilities, defective parts, buffering effects, scheduled maintenance, operation experience and other pertinent variables. The simulation will also evaluate the probability of meeting production requirements while operating in a real time environment considering the varying production conditions described above. Procedures used are making use of computer methods already developed by Government or private contractors. Several computer techniques within ARRADCOM are currently being used for line simulation. Examples of such techniques are GPSS, GALS, SIMSCRIPT

and GENMOD. Of the four mentioned, GENMOD is being used by this effort for simulating a MPTS line because of its simplicity to the user as well as its compliance with analysis requirements. Operation data was taken from an ammunition plant line when it was running at near 100% capacity. This line is being simulated and results are being compared with actual acceptable production output. The GENMOD program is also simulating the NORRIS Industries M483 MPTS line. Information obtained from proveouts at both Norris Industries and National Presto is currently being used to simulate the Mississippi Army Ammunition Plant (MAAP) M483 MPTS line with the results being used as helpful criteria for the evaluation of proposals for the MPTS material handling equipment. The Louisiana Army Ammunition Plant (LAAP) M483 line is also being simulated by GPSS. The GPSS technique stresses queuing theory and the resulting model will analyze the indexing carousel located in the M483 Rough turn area at LAAP.

The benefits of this effort will be proven simulation programs/models which will be used to accurately predict equipment requirements, bank and buffer sizes and expected thruput of metal parts ammunition lines.

Additional information about this project may be obtained by contacting Mr. W. O'Neill, ARRADCOM, Autovon 880-3596 or Commercial (201) 328-3596.

## **900 MATERIALS HANDLING AND STORAGE**

Handling of Hazardous Munitions

Hazardous Benching Operations

## 900 MATERIALS HANDLING AND STORAGE

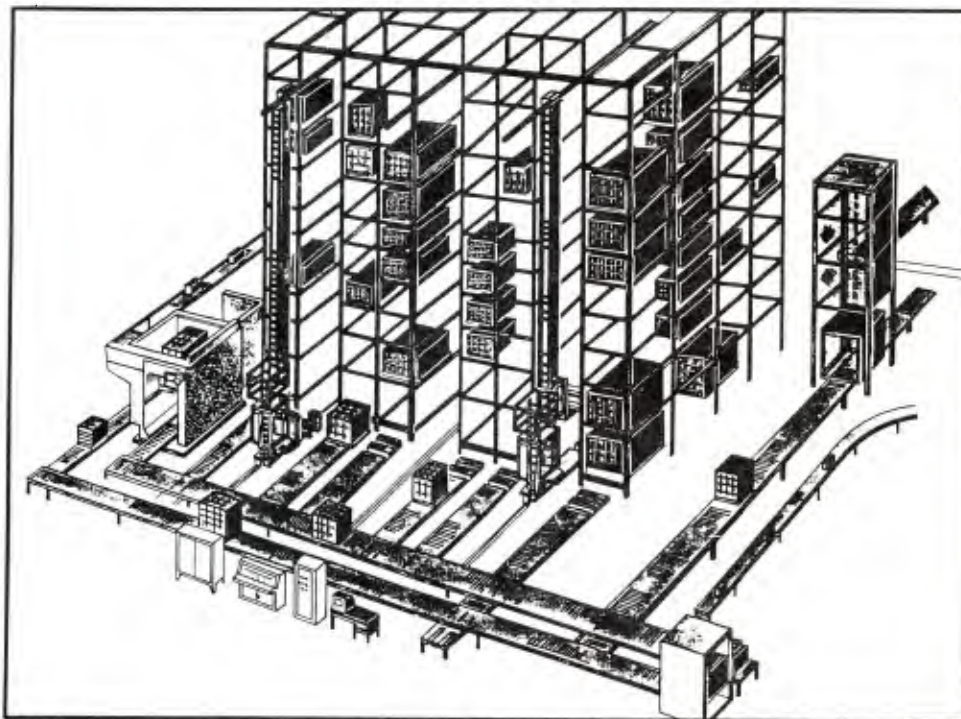


Figure 23

This area involves the integration of computer aided technology to aid in material handling. Objectives here include complying with OSHA and EPA standards and reducing costs and materials handling time. An automated material storage, handling and retrieval system is illustrated in Figure 23.

Robots provide the most flexible form of automation for parts and material handling, fabrication and assembly tasks and programmable robots may be reprogrammed to perform various tasks as required by changing workload demand and product mix.

### HANDLING OF HAZARDOUS MUNITIONS

An ever increasing emphasis on safety in the Department of the Army is spurring a trend to automate and remotely control the handling of hazardous munitions and components.

The application of automated techniques to such operations as explosive packaging, assembly of sensitive components, and demilitarization of obsolete munitions are only a few of the many areas in which automated material handling is beneficial. The Army has found that the use of robotics is becoming more and more useful in the hazardous munitions environment to fulfill automation needs. The industrial robot possesses the versatility of movement capabilities necessary to successfully perform complex munitions operations.



Louisiana Army Ammunition Plant (LAAP) procured its first two Manipulator/Robots in 1972. Today LAAP employs eight Manipulators (custom built robots) in the press area, which are equipped with General Electric Logitrol controls. In addition LAAP has six general type robots, these are: two API Robots in the M107 nosing area, two AMF Versatron Robots in the M483A1 slot and deburr operation, and two AMF Versatron Robots in the M483A1 machine ogive operation. To date, the eight custom made manipulators seem to perform most satisfactorily. In addition to these 14 robots the LAAP Material Handling System, for the metal parts manufacturing facility, is equipped with Allen Bradley PLC-2 Controllers which can be reprogrammed whenever necessary.

Additional information may be obtained from Mr. C. E. Baldwin, LAAP, Autovon 435-5443 or Commercial (318) 459-5443.

An example of the use of Robotics for handling explosive materials in loading, assembling and packaging plants was accomplished by the US Army Armament Research and Development Command (ARRADCOM) under an MMT effort (1155) completed in 1975. In this effort two remotely operated Versatron industrial robots were proven successful in application to demilitarize bombs by the decluster of the M34 cluster bombs. The robot used is a programmable automatic transfer, handling, and positioning machine that is electronically controlled and hydraulically operated to achieve either point to point or continuous three dimensional path motion.

This effort also developed and demonstrated the successful packout operation of M18 grenades. The robot was successfully programmed to simultaneously pack sixteen M18 grenades into wooden cases, see Figure 24.

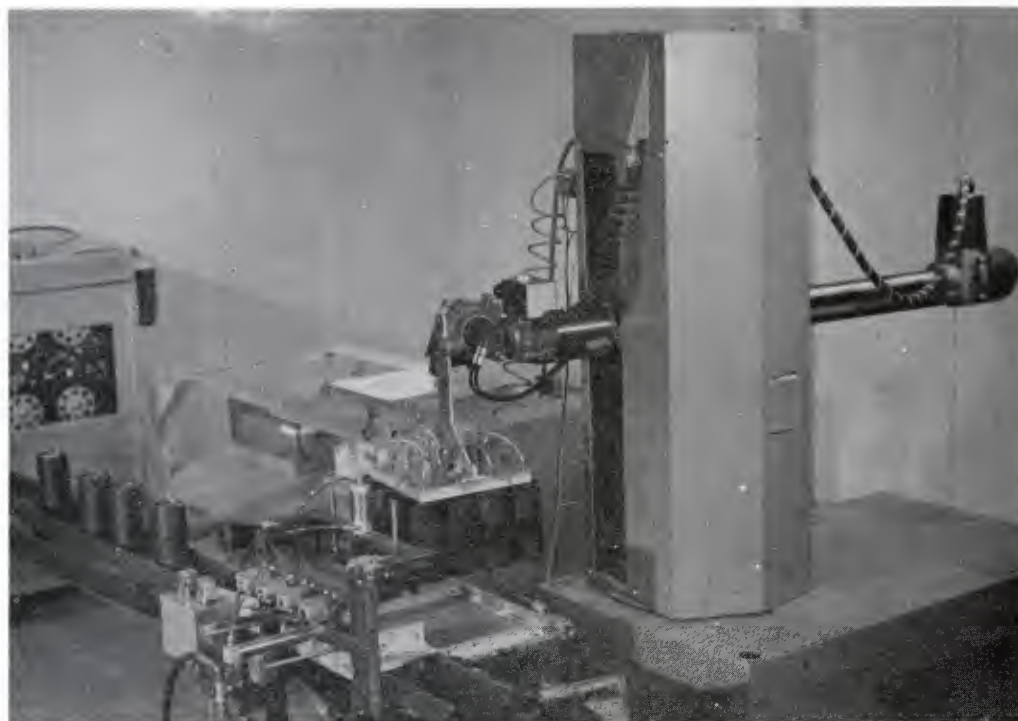


Figure 24

This effort demonstrated the functional feasibility of using a robot system to locate, grasp, and remove objects in even an unpredictable location. A lesson learned is that benchmark requirements for the cycle time to perform certain key operations should be considered as part of the robot system requirements.

The effort accomplished here confirmed that industrial robots can perform a definite role in improving Army munition facilities operations where human operators would otherwise be subjected to unsafe environments for extended periods of time.

Additional information is available from Mr. J. Abbott, ARRADCOM, Autovon 584-3418 or Commercial (301) 328-3418.

## **HAZARDOUS BENCHING OPERATIONS**

Another MMT effort (7928) currently in progress by the US Army Armament Materiel Readiness Command at Watervliet Arsenal is involved with applying an industrial robot to perform hazardous benching operations. This effort will replace manual operations which take approximately 4 hours with a considerable amount of time spent grinding radii on the ends of internal segmented threads where visibility is poor. The operator uses a high speed air driven tool which causes a considerable amount of air turbulence. While performing this operation the worker, even though using a full face shield, is inflicted with too high a frequency of eye injuries. The application of an industrial robot will eliminate the hazardous aspect of this particular benching operation and will also reduce the metal grinding time needed to complete the task.

Additional information may be obtained by contacting Mr. V. H. Montuori, ARRADCOM, Autovon 974-4170, or Commercial (518) 266-4170.

## **1000 TEST, INSPECTION AND EVALUATION**

Computer Controlled Test Equipment (EQUATE)

Computer Controlled Laser Inspection System

## 1000 TEST, INSPECTION AND EVALUATION

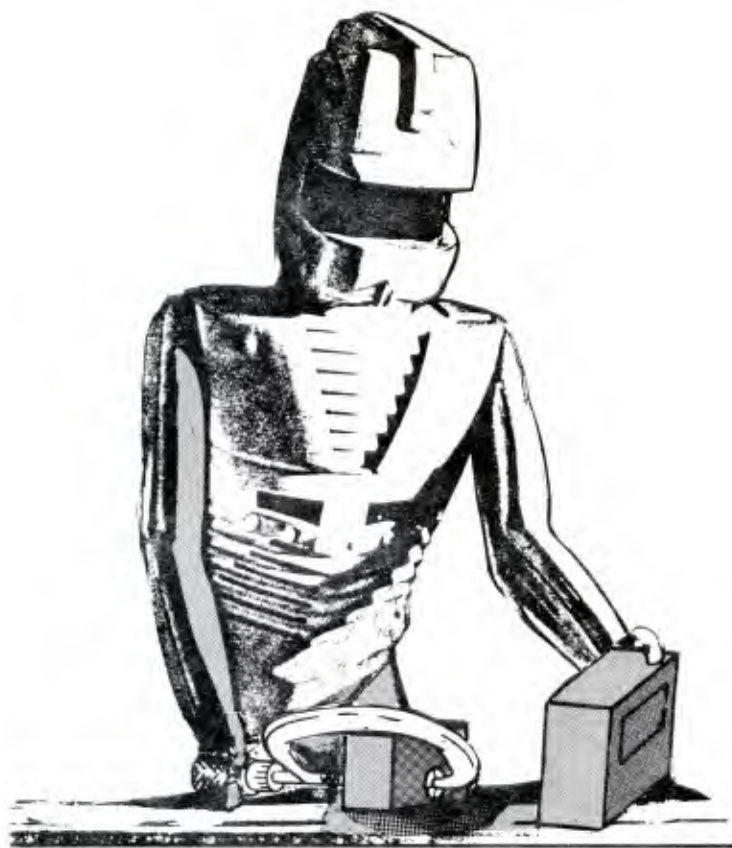


Figure 25

Develop and transition real time, computerized, nondestructive testing techniques for use in fabrication and assembly operations. Emphasis is put on automatic, in-process inspection and decision making without human intervention. The concept is illustrated by the use of a robot in Figure 25.

### COMPUTER CONTROLLED TEST EQUIPMENT (EQUATE)

The US Army Electronics Command supported a completed MMT effort (9353) for the automatic examination of electronic components and systems. This effort developed Electronic Quality Assurance Test Equipment (EQUATE) that has successfully been used in all three Services.

EQUATE (AN/USM-410) is a standardized computer controlled test system that can be used for testing a large number of diversified electronic systems such as avionics, guidance/control, multiplexing, communications, and radar units. This standardized test system has been found capable of economically performing 100% quality acceptance (QA) testing of more small replaceable assemblies (SRAs) than any other system evaluated. Savings in using the EQUATE system have been substantial. Air Force contractors for

the Airborne Warning and Control System (AWACS) indicate the checkout budget for these systems, using EQUATE, ranged from one to two percent of total cost. Other firms not using EQUATE but using less sophisticated test systems report their tests average 5 to 10 percent of total cost. In some instances, using EQUATE, radio tests which previously had required 24 hours have been tested in 10 minutes. With this system's reduction in required test times, it is now functionally feasible to perform 100% testing of all SRAs at manufacturer's plants. A follow-on effort is planned for FY82 to reduce the cost of the system and thereby make available more economical test equipment.

What makes EQUATE different from its predecessor test equipment is the concept of utilizing a computer. Computer software directs a frequency synthesizer to generate the precise input voltages and waveforms, apply them to the appropriate pins on the test unit, and then measure the output waveforms from a transmitter and analyze the signals mathematically. Distortion, power level, base frequency and other parameters may also be tested. With this test system there is no need for an array of AC and DC power supplies for signal generating units.



Figure 26

The EQUATE system, see Figure 26, consists of a NOVA 800/D.G. S130 Eclipse computer, a tape reader and input keyboard, various alternating and direct current voltage converters, radio test set adaptors, several high frequency signal and measuring units, a cathode ray tube and a line printer.



EQUATE's software programming language is an extension of ATLAS (Abbreviated Test Language for Avionics System), and permits an engineer with little software experience to program with the aid of a reference manual.

There is currently an on-going MMT effort (9773) directed towards reducing the time for preparation of the automatic analog circuit production test programs in conjunction with EQUATE. This effort called the ATLAS Generator (AGEN), minimizes both engineering and computer time in developing analog test programs.

There has been a successful demonstration of the application of AGEN to EQUATE at Tobyhanna Army Depot. For more information on AGEN contact Mr. Roy Zelenka, Communications Research and Development Command (CORADCOM), Autovon 992-5676 or Commercial (201) 544-5676.

EQUATE is also being built in a van version. The AN/VMS - 410 van version of EQUATE will be located at plants that build the Army Attack Helicopter (AAH) and the Blackhawk. Some systems will support TOW and Firefinder missiles while others will be used at depots for post-deployment test support.

Additional information on EQUATE may be obtained by contacting Mr. James F. Kelly, CORADCOM, Autovon 992-3276 or Commercial (201) 532-3276.

## COMPUTER CONTROLLED LASER INSPECTION SYSTEM

The US Army Missile Command (MICOM) is currently supporting an MMT effort (3169) for the automatic optical inspection of printed circuit boards and components. The resulting production prototype of the optical scan printed wiring board (PWB) inspection system will consist of a mini-computer and computer peripherals, troubleshooting diagnostic software, a low power helium neon laser, an x-y moving iron galvanometer scanner and several folding mirrors. A unique shadow signature is detected by silicon photodiodes located at optimum geometry and fed into the computer. The system will automatically inspect PWB's for missing components and improperly clinched leads, along with inspection for flaws in wave soldering on boards. For example a 400 lead board can be scanned for component presence and lead clinch in  $4\frac{1}{2}$  seconds, while the same board can be scanned for solder bridges in less than 2 seconds. These specific applications are cost effective and it is estimated they will allow payback of system cost in less than one year on large production lines.

A production-oriented prototype, in the final state of assembly, was scheduled to be completed in September 1980. Chrysler is planning to implement this system in its production lines and to build additional systems for commercial sales.

Additional information about this effort may be obtained by contacting Mr. Robert L. Brown, MICOM, Autovon 746-5742 or Commercial (205) 876-5742.

## **1100 CONTINUOUS FLOW PROCESS**

Continuous Production of Propellant

Continuous TNT Manufacturing

Black Powder Process

## 1100 CONTINUOUS FLOW PROCESS

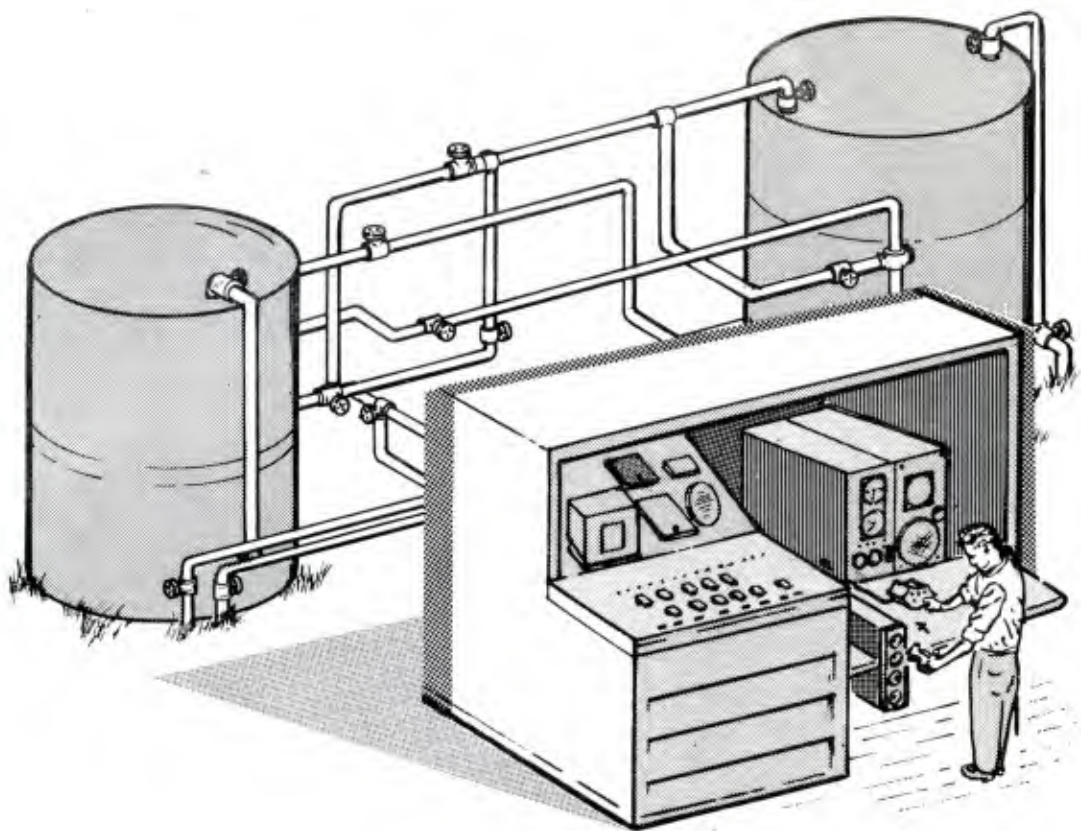


Figure 27

This area addresses the range of manufacturing processes that, for the most part, are continuous with minimum human interaction. The Continuous Automated Production of Solvent is illustrated in Figure 27, as an example of a continuous flow process.

### CONTINUOUS PRODUCTION OF PROPELLANT

The US Army Armament Research and Development Command (ARRADCOM) is currently supporting an MMT effort (4202) for providing prototype equipment for the continuous automated production of solvent type multi-base cannon propellant (CAMBL).

This effort is providing the design, procurement and evaluation of an automated, continuous process from thermal dehydration to cutting, and utilize the present batch method, from drying to final pack-out. This effort also supports the planned Facilities projects at Radford AAP (Project 5 80 2875) and at Sunflower AAP (Project 5 86 2899). At Radford AAP the designed system utilizes two Digital Equipment Corporation PDP8 computers interconnected to form a configuration termed "PDP-88" system and in this

configuration one computer maintains responsibility for direct digital control (DDC), of a propellant line and the other computer serves a supervisory function, ready to take over control of the line should the DDC computer fail.

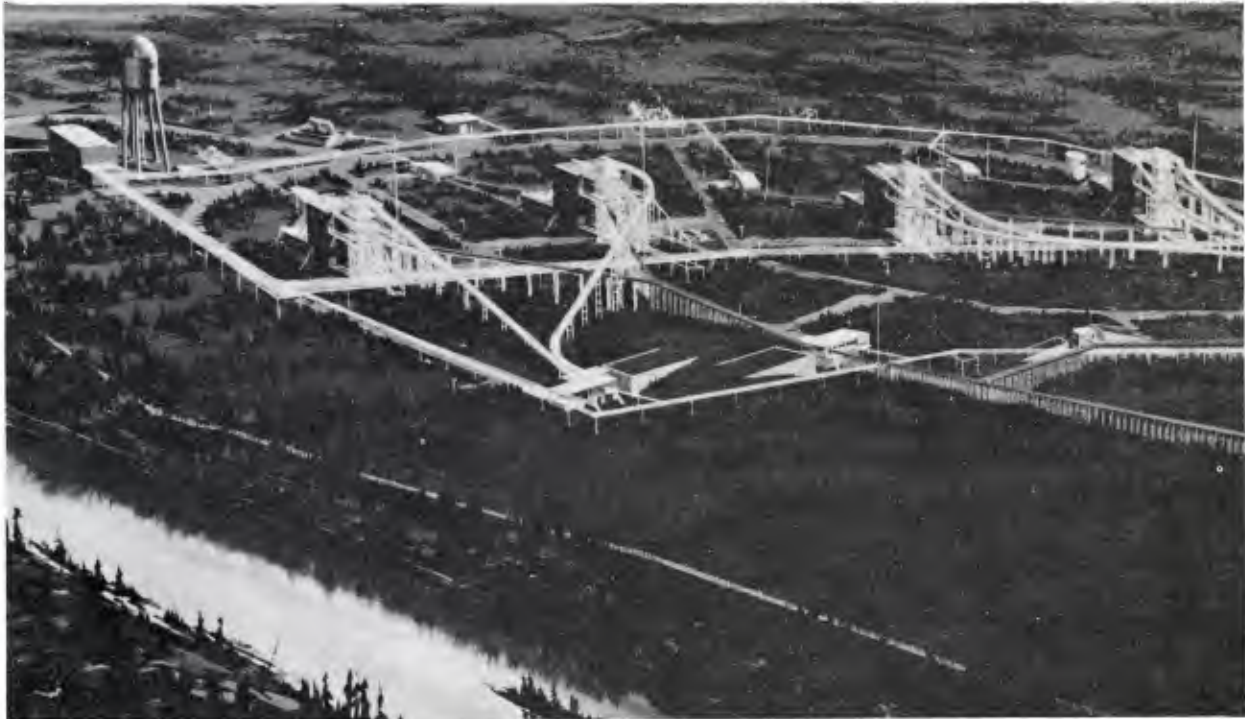


Figure 28

The CAMBL facility, with the dedicated process controller, permits a continuous flow of propellant between each line operation without the holding periods or fluctuations in environment which are associated with the greater exposed distances on the existing batch facility, see Figure 28.

Any significant change in the process cannot be implemented without being authorized or programmed into the process controller. This eliminates unauthorized process variations being introduced.

The dedicated process controller, with alarm functions and ability for self-diagnostics, allows immediate notification of equipment failure so that redundant systems can be activated or modified or repairs effected.

The line utilizes the latest technology and is designed to operate at 2.4 million pounds of propellant per month. The design reduces personnel exposure to hazardous material, reduces number of operating personnel as well as land area requirements and also reduces the cost of manufacturing the propellant.

Additional information may be obtained by contacting Mr. Leo P. Lempicki, ARRADCOM, Autovon 880-3637 or Commercial (201) 328-3637.



## CONTINUOUS TNT MANUFACTURING

ARRADCOM has supported an MMT effort (4147) for the application of computer control to continuous TNT manufacture. In the mid 1960's the United States Army made a decision to modernize the batch TNT line at an Army Ammunition Plant (AAP). This modernization involved replacing the old World War II vintage batch process TNT lines with a new continuous nitration and purification process. Radford AAP, in the mid 1960's was the first plant to install the new continuous process line. In the late 1960's and early 1970's, ten more continuous process lines were installed; two at Radford AAP, five at Newport AAP, and three at Joliet AAP. The new process was later modified, utilizing remote Direct Digital Control (DDC), and was successfully installed at the Volunteer AAP.

This effort (4147) was executed in support of modernization of TNT production facilities at Volunteer (AAP) with results being applicable to all TNT producing AAP's. Efforts under this project resulted in design, procurement, installation and evaluation of a prototype direct digital control system for a single TNT line at Volunteer AAP. The prototype system consists of four major sub-systems: field equipment (valves, sensors, transmitters, cables, etc.), interface hardware (analog signal conditioning and conversion gear), control room hardware, and software. The system is based on a dual computer design (Foxboro's Model PCP-88) in which one computer controls the process while the other serves as back-up and, in addition, executes supervisory calculations, see Figure 29.



Figure 29



The objectives of this effort were to improve the safety, reliability and efficiency of the continuous TNT process.

Installation and mechanical checkout of the system took place between October and December 1974, with the first ever acceptable TNT from a computer controlled line being produced on 22 November 1974.

The desirability and advantage of remote, automated control and operation of continuous TNT lines was clearly demonstrated under this project. Analysis of production data indicated that a 16% increase in production rate was achieved compared to the best previous rate attained under manual control.

As a result of the successful development of the prototype DDC system on line at Volunteer AAP a similar system was included as part of the TNT line construction project at Joliet AAP.

Effort 4147 also initiated a computer controlled continuous TNT prototype line at Radford AAP. A decision to delete the supervisory computer from the TNT control system at Radford AAP was made, which resulted in only an analog system being selected to be installed. The analog system can be interfaced with a supervisory computer at a later date. The line is currently being equipped with Foxboro Videospec analog (through Facilities Project 5XX 5901) equipment, which will be used to control cooling water flow and ingredient feed rates.

Additional information may be obtained by contacting Mr. Raymond Goldstein, ARRADCOM, Autovon 880-4122, or Commercial (201) 328-4122.

## **BLACK POWDER PROCESS**

Black powder facilities at Indiana Army Ammunition Plant (IAAP) were modernized under Facilities effort (2084) beginning in 1974. Materials processed through this facility are transported by conveyor and handled by automated equipment. The computer and the programmable controllers with the aid of closed loop sensor feedback circuits control the quantity and quality of the end product during the whole manufacturing procedure. In the process control center the operation is displayed on a process flow panel with sensor condition lights which flash when a fault condition occurs, an audible alarm tone is sounded and all or portions of the process are brought to a halt until the fault is cleared and the controllers are reset by the operators.

The batch glazing barrel processes have been replaced by the "Harperizer." The Harperizer uses continuous-flow glazing increasing output and safety.

ARRADCOM is supporting an MMT effort (4303) at IAAP to establish product, process, and source material requirements, and develop test methods compatible with a continuous process.

Additional information may be obtained by contacting Mr. J. Craig Allen, ARRADCOM, Autovon 880-3212, or Commercial (201) 328-3212.

## **APPENDICES**

- A - CAM MMT and Facilitization efforts
- B - CAM Steering Group Members
- C - DARCOM CAD/CAM Systems
- D - Distribution

## **APPENDIX A**

### **CAM MMT AND FACILITIZATION EFFORTS**

## **CAM MMT AND FACILITIZATION EFFORTS**

This appendix contains a listing of CAM related MMT efforts and Facilitization efforts referred to in the body of this document. The information is presented by CAM technology thrust areas corresponding to the thrust area in the narrative portion where they were originally introduced. Data presented for each effort includes the effort number, command code, fiscal year(s) per effort, cost, cycle, Project Engineer, telephone numbers and title of the effort. The MMT efforts also include problem and solution statements while the Facilitization efforts include the Facility affected.

### **EXPLANATION OF DATA PRESENTATION**

1. EFFORT NO. - MMT or Facilitization effort number.
2. COMMAND CODE - Refer to list of command codes and corresponding major subordinate commands or activities.
3. FY - Fiscal Year for MMT or Facilitization effort.
4. COST - Total cost in thousands of dollars
5. CYCLE - Funding status of corresponding Fiscal Year effort.
6. Project Engr. - Name of Project Engineer for the effort.
7. Autovon - Autovon telephone number.
8. Commercial - Commercial telephone number.
9. Title - MMT or Facilitization effort title.
10. Problem - Description of the problem the MMT effort addresses.
11. Solution - Description of how the MMT effort proposes to solve the problem.
12. Facility Applied - Name of Facility which the Facilitization effort supports.



# COMMAND CODES FOR MAJOR SUBORDINATE COMMANDS OR ACTIVITIES

<u>Command Code</u>	<u>Major Subordinate Command/Activity Acronym</u>
0	TECOM
1	AVRADCOM
2	CERCOM
3	MICOM
4	TACOM
5	ARRCOM (Ammo)
6	ARRCOM (Weapons)
7	TSARCOM
8	ARRADCOM (Ammo)
9	ARRADCOM (Weapons)
D	DARCOM
E	MERADCOM
F	CORADCOM
H	ERADCOM
M	AMMRC
Q	NARADCOM
R	MICOM
T	TACOM
I	IBEA
G	DESCOM

100 ARCHITECTURE  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
1071	R	80	100	Approved
		81	1000	Apportionment

Project Engr: G. Little  
Autovon: 746-3848  
Commercial: (205) 876-3848

Title: Hybrid Integrated CAD and Manufacturing (HICADAM)

Problem: Hybrid circuit design and manufacture is labor intensive. The CAD data base has not been extended to manufacturing process control.

Solution: Analyze functional flow and manufacturing process controls and modify the design data base to make it capable of defining functions, input, output, controls and interfaces. Use ICAM methodology to develop system architecture.

1075	R	80	300	Approved
		81	2500	Apportionment
		82	1000	Budget

Project Engr: G. Little  
Autovon: 746-3848  
Commercial: (205) 876-3848

Title: Electronics Computer Aided Manufacturing (ECAM)

Problem: Although integrated circuits, hybrid circuits, printed circuits and cables are designed on a computer, there is little computerized control of processes used to produce these items. A master plan is needed to define the area and requirements.

Solution: Develop a DOD master plan for computer-aided design and mfg. of electronic systems. Use Air Force's ICAM and NASA's IPAD programs to define CAD/CAM and electronic technologies to make integrated circuits, hybrid circuits, printed circuits, and cables.

100 ARCHITECTURE  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
6736	5	76	40	Completed
		78	100	Approved
Project Engr:	S. Hart	79	391	Approved
Autovon:	880-3721	80	315	Approved
Commercial:	(201) 328-3721			

Title: Tech Readiness Accel thru computer Integrated Mfg (CAM)

Problem: The lead time required to bring production lines to mobilization maximum is intolerably excessive. A critical deterrent is the extreme shortage of toolmakers and machinists.

Solution: The development and implementation of a computer integrated manufacturing system will significantly reduce the requirement for highly skilled craftsmen.

200 FABRICATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
5082	T	79	440	Approved
		80	880	Approved
Project Engr:	S. Goodman	81	880	Budget
Autovon:	273-1814	82	750	Budget
Commercial:	(313) 573-1814			
Title: Flexible Machining Systems Pilot Line for TCV Components				
Problem: Parts for tracked combat vehicles are typically not manufactured in large quantities. Because of this, mass production technologies that result in lower production costs are not used.				
Solution: The advantages of mass production can be realized in producing medium quantity size lots by a concept known as Flexible Machining Systems. This project will advance the FMS technology making it feasible to utilize FMS for the Mfg. of Army Materiel.				
5085	T	77	370	Completed
		78	948	Approved
Project Engr:	S. Goodman	80	237	Approved
Autovon:	273-1814			
Commercial:	(313) 573-1814			
Title: Production Techniques for Fabrication of Turbine Recuperator				
Problem: Current method requires a large number of welds to fabricate component.				
Solution: Establish procedure utilizing a laser beam to greatly increase welding speed.				
6522	5	73	358	Completed
Project Engr:	R. Stanton			
Autovon:	880-5752			
Commercial:	(201) 328-5752			
Title: Computer Monitor + By Closed Loop Techn of Arty Shell Weld				
Problem: At present there is an inadequate control of both arch length and temperature which causes the specified hardness to be exceeded.				
Solution: Adapt a computer aided monitor and process control system capable of controlling the arc length and temperature.				

200 FABRICATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
6200	5	70	249	Completed
		71	2875	Completed
Project Engr:	J. Goldman	72	4552	Completed
Autovon:	348-6052	73	3425	Completed
Commercial:	(215) 831-6052	74	2460	Completed
		75	1750	Completed
		76	1300	Approved
		77	1218	Approved

Title: Small Caliber Ammo Process Improvement Program

Problem: The existing batch process (over 30 years old) consists of manual material transport, limited production rates, and outmoded inspection systems.

Solution: Use an integrated, continuous process production system from raw materials to packed-out ammunition.

6753	5	78	475	Approved
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Project Engr: E. Rempfer  
Autovon: 880-3737  
Commercial: (201) 328-3737

Title: Methods for Orienting and Feeding Small Cal Ammo

Problem: The existing batch process uses slow parts feeders. Feeders initially developed for the 5.56mm MOD program have had mechanical problems and have not achieved the required efficiency.

Solution: Utilize new feeder technology to provide feeders with virtually 100% fill capability and improved ruggedness.

7103	1	76	435	Completed
		77	305	Completed

Project Engr: F. Reed  
Autovon: 693-1625  
Commercial: (314) 263-1625

Title: Improved Mfg. Blisk/Impeller Turbine Engine Compressor Parts

Problem: Integral blades disks, and impellers, when manufactured by single spindle tracing equipment, are expensive.

Solution: Develop the process to manufacture these components by one of several roughing methods, finish milling by numerically controlled multi spindle machines and abrasive flow finishing.



200 FABRICATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
7246	6	73	75	Completed
		76	5	Cancelled

Project Engr: C. Laross  
 Autovon: 974-5611  
 Commercial: (518) 266-5611

Title: Breech Ring Manufacture by Automation

Problem: A prior year study has identified many areas where cost reductions are possible in the mfg. of the 105mm M68 Breech Ring.

Solution: Selected operations will be combined. Equipment will be modified resulting in reduced time and cost.

8104	6	79	100	Approved
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Project Engr: A. Wakulenko  
 Autovon: 974-5611  
 Commercial: (518) 266-5611

Title: Improved Breech Block Manufacturing

Problem: The wide variety of machine table standards involves expensive and space wasting alternatives to specifically designed manufacturing processes.

Solution: A specifically designed manufacturing facility using a palletized system of fixturing, maximum tool efficiency, and reduced material handling.

9351	2	71	272	Completed
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Project Engr: S. Sokolove  
 Autovon: 995-2046  
 Commercial: (201) 535-2046

Title: Microwave Transistors Electron Beam Machining

Problem: Manually applied photomasking in the production of semiconductors is slow and accuracy of resulting process needs improvement.

Solution: Computer controlled Electron-beam exposure of photoresist on the surface of silicon wafer will improve quality and speed of process.

200 FABRICATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
9631	2	76	783	Completed

Project Engr: W. Glendinning  
 Autovon: 995-4396  
 Commercial: (201) 544-4396

Title: IC Fabrication using Electron Beam Technology

Problem: Extremely high speed real-time signal processing integrated circuits require submicron line widths and spacing. Current electron beam processing can provide dimensional resolution at the one to two micron (micrometer) range.

Solution: Establish production processes for application of higher resolution resist materials and electron beam control to yield submicron resolution.

9639	2	74	713	Completed
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Project Engr: S. Kramer  
 Autovon: 354-6265  
 Commercial: (703) 664-6265

Title: Automation of Production Methods - Multi Alkali photocathode

Problem: Present process for multialkali photocathodes has low yield.

Solution: Mechanize and automate the deposition techniques.

200 FABRICATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
9679	2	72	225	Completed
		76	395	Completed

Project Engr: D. Ruppe  
 Autovon: 995-4251  
 Commercial: (201) 535-4251

Title: Numerical Control Language Evaluation

Problem: There are approximately 17 major numerical control lathe languages currently in popular use.

Solution: Evaluate each language and its advantages and disadvantages for specific lathe operations.

9750	2	74	700	Completed
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Project Engr: D. Jenkins  
 Autovon: 354-1725  
 Commercial: (703) 664-1725

Title: Fab of 18MM Image Intensifier Tubes by Batch Processing

Problem: The 18MM Wafer Tube is currently processed in a single-unit (Port) Vacuum processing station.

Solution: Utilize batch processing methods and techniques in the areas of photocathode formation, MCP and phosphor screen outgassing and vacuum sealing of the tube.

200 FABRICATION  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	SUB TASK	FY	COST	CYCLE
2146	5		82	4400	Budget
Project Engr: S. Ward Autovon: 880-4016 Commercial: (201) 328-4016  Title: MOD - Scamp Line 1 Comp  Facility: Lake City AAP					
2153	5		89	11,000	Pre-Budget
Project Engr: S. Ward Autovon: 880-4016 Commercial: (201) 328-4016  Title: MOD - 7.62 Ball Tracer Conv - Scamp  Facility: Lake City AAP					
2194	5	A	72	3196	Completed
		B	73	4516	Approved
		C	77	729	Approved
Project Engr: S. Ward Autovon: 880-4016 Commercial: (201) 328-4016  Title: MOD - Sm Cal Ammo Prod Eqmt New Con  Facility: Lake City AAP					
2195	5		75	40,212	Approved
		A	89	1,000	Pre-Budget
Project Engr: S. Ward Autovon: 880-4016 Commercial: (201) 328-4016  Title: MOD - 5.56 Pdn Eqmt and Bldg. Rehab					

200 FABRICATION  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	SUB TASK	FY	COST	CYCLE
2205	5	A B	72 73	2,558 8,547	Completed Approved
Project Engr: S. Ward Autovon: 880-4016 Commercial: (201) 328-4016  Title: MOD - 5.56 Prod Eqmt f/sm Cal Ammo  Facility: Lake City AAP					
2208	5		83	1,600	Pre-Budget
Project Engr: S. Ward Autovon: 880-4016 Commercial: (201) 328-4016  Title: MOD - 5.56 Ball/Tracer Saw  Facility: Lake City AAP					
2396	5	B C	72 73	7,955 25,632	Completed Approved
Project Engr: S. Ward Autovon: 880-4016 Commercial: (201) 328-4016  Title: MOD - Fac f/5.56mm Mfg.  Facility: Lake City AAP					
2576	5		77	24,708	Approved
Project Engr: J. Mok Autovon: 880-4084 Commercial: (201) 328-4084  Title: EXP - 155mm M483 Shell Mpts  Facility: Louisiana AAP					



200 FABRICATION  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	SUB TASK	FY	COST	CYCLE
2974	5		74	19,688	Approved
Project Engr: T. Gutch Autovon: 880-4084 Commercial: (201) 328-4084  Title: EXP - 8" M509 Proj MPTS  Facility: Scranton, AAP					
2975	5		74	4,098	Completed
Project Engr: Y. Ywong Autovon: 880-4084 Commercial: (201) 328-4084  Title: MOD - 155mm M483 Proj MPTS  Facility: Chamberlain					
3142	5		79	74,600	Approved
Project Engr: C. Gagnon Autovon: 880-4086 Commercial: (201) 328-4086  Title: EXP - 155mm ICM Complex  Facility: Mississippi AAP					
3146	5		76	4,413	Approved
Project Engr: J. Kolisek Autovon: 880-4084 Commercial: (201) 328-4084  Title: EXP - 155mm M483 Shell MPTS  Facility: Norris Industries					

200 FABRICATION  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	SUB TASK	FY	COST	CYCLE
3508	5		77	35,823	Approved
Project Engr: J. Kolisek Autovon: 880-4084 Commercial: (201) 328-4084  Title: EXP - 8" ICM M509 Proj MPTS  Facility: Norris Industries					
5025	T		77	65,200	Approved
			78	121,668	Approved
Project Engr: Maj. R. Ramseth Autovon: 273-2480 Commercial: (313) 573-2480  Title: EXP - Planned Prod of XM1 Tank  Facility: Lima Army Tank Plant					
6036	T		82	6,665	Budget
Project Engr: Maj. R. Ramseth Autovon: 273-2480 Commercial: (313) 573-2480  Title: PSR - XM1 Tank  Facility: Detroit Army Tank Plant					
6037	T		82	11,072	Budget
Project Engr: Maj. R. Ramseth Autovon: 273-2480 Commercial: (313) 573-2480  Title: PSR - XM1 Tank  Facility: Lima Army Tank Plant					

200 FABRICATION  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	SUB TASK	FY	COST	CYCLE
8169	7		77	3,940	Approved
			78	2,981	Approved
			79	2,500	Approved
			80	2,000	Approved
			81	421	Apportionment
			82	2,486	Budget
			83	4,002	Pre-Budget
			84	4,264	Pre-Budget

Project Engr: A. Goldberger  
 Autovon: 693-0496  
 Commercial: (314) 263-0496

Title: IPF - GE - T700 Turbine Engine

Facility: GE Aircraft Engine Group, Hooksett Operation

300 DATA BASE/DATA AUTOMATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
4456	5	76	100	Completed

Project Engr: H. Pebly  
Autovon: 880-4222  
Commercial: (201) 328-4222

Title: Materials Property Data Information System

Problem: There is no rapid access to information in support of Army production engineering functions.

Solution: Computerize appropriate material property and processability data as related to the many manufacturing processes.

4568	4	7T	500	Approved
		74	100	Completed
		75	220	Completed

Project Engr: D. Johnson  
Autovon: 273-1880  
Commercial: (313) 573-1880

Title: Tech Data/Configuration Management System (TD/CMS)

Problem: There is no standard TD/CMS.

Solution: Develop a DARCOM wide standard TD/CMS and improved technical data packages.

7802	6	78	195	Approved
		79	282	Approved

Project Engr: R. Kirschbaum  
Autovon: 793-5363  
Commercial: (309) 794-5363

Title: Establish Machine Tool Performance Specifications

Problem: Procurement, acquisition, and application of new and used machine tools are both physically and economically inefficient.

Solution: Tests will be designed and procedures established for testing machine tools and determining overall performance efficiency. Guidelines will be written for procurement of machine tools according to specific performance requirements and efficiencies.

400 CAD/CAM INTERACTION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
202N	A	74	300	Completed

Project Engr: L. Campbell  
 Autovon: 955-2347  
 Commercial: (617) 653-1000, ext. 2347

Title: Computer Aided Pattern Fabrication Techniques

Problem: Patterns used in the production of clothing are new hand graded, i.e. increase and decrease size from one intermediate matter pattern.

Solution: Improve process for making clothing patterns by developing software to grade clothing patterns automatically.

4561	4	75	134	Completed
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Project Engr: T. Wassel  
 Autovon: 273-1814  
 Commercial: (313) 573-1814

Title: CAD/CAM for Closed-Die Forging of Trak Shoes and Links

Problem: Forging dies are designed and manufactured through trial and error methods. Considerable scrap losses, unexpected die wear and break-age raise manufacturing costs.

Solution: Develop computer aided techniques for manufacturing forging dies by using N/C machining methods. Optimize design and life of the forging dies.

5014	T	77	560	Approved
		78	415	Approved

Project Engr: T. Wassel  
 Autovon: 273-2065  
 Commercial: (313) 573-2065

Title: Improved Foundry Castings Utilizing CAM

Problem: Foundry casting processes are wasteful of raw materials and energy.

Solution: Optimize casting processes by digital computer analysis of advanced fluid flow and thermal activity.



400 CAD/CAM INTERACTION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
5024	T	78	200	Approved
		79	205	Approved
Project Engr:	T. Wassel	81	350	Budget
Autovon:	273-2065	82	640	Budget
Commercial:	(313) 573-2065			

Title: Gear Die Design and Mfg Utilizing Computer Technology

Problem: The control of dimensional tolerances of forged bevel gears presents a unique problem since these gears are not mfg. to theoretical equations. The bevel gear is not defined dimensionally but is presented as requirements for tooth bearing patterns.

Solution: This program will eliminate the current trial and error methods by utilizing CAD/CAM methods and interactive graphics techniques. Excessive scrap, unexpected die wear and breakage, and the high cost of forging dies will be addressed.

6716	5	76	250	Completed
		77	295	Completed
Project Engr:	F. Lee	79	306	Approved
Autovon:	880-4462	81	157	Apportionment
Commercial:	(201) 328-4462			

Title: Math Model of Forming Operations for Artillery Design

Problem: Trial and error methods and the absence of proven automated design techniques for tooling cause unexpected failures in forming operations and delays in startup of ammunition production lines.

Solution: Develop analytical models and automated tool design methods of critical metal forming operations. Tool designs thus generated will be tested in a production setting to verify the computer models. Proven models are applicable to current and future items.

400 CAD/CAM INTERACTION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
6943	6	70	90	Completed
		71	222	Completed
Project Engr:	L. Liuzzi	72	300	Completed
Autovon:	974-5827			
Commercial:	(518) 266-5827			
Title: Engineering Study and Application of Metallurgical Process to Manufacture of Cannon				
Problem: The use of solid forgings that are trepanned, machined to O.D. and I.D. configurations, rifled by broaching or draw cutting, leaves much to be desired.				
Solution: Rotary-Forging equipment has been successfully applied to small arms barrels since World War II. This process can be scaled up to large heavy-wall tubes.				
7220	6	72	140	Completed
Project Engr:	S. Hart			
Autovon:	880-3721			
Commercial:	(201) 328-3721			
Title: Gen. Purpose Machine Tool Mini-Computer Directed NC				
Problem: Part Programming of Numerical Control Machine Tools was done with Manual Programming or Time Share with a commercian vendor.				
Solution: Establish interactive graphics design workstation with computer assisted part programming. Transmission of machine control unit instructions are hardwired for Direct Numerical Control.				
7588	6	75	200	Completed
		76	418	Completed
Project Engr:	L. Liuzzi	77	260	Completed
Autovon:	974-5827			
Commercial:	(518) 266-5827			
Title: Rotary Forge Integrated Production Technology				
Problem: Optimize the integrated tube forging facility at Watervliet Arsenal.				
Solution: Initiate production of thick wall tubes by rotary forging.				

400 CAD/CAM INTERACTION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
7649	6	77	100	Completed
		78	102	Completed

Project Engr: R. Kalkan  
Autovon: 793-5504  
Commercial: (309) 794-5504

Title: Computerized Powder Metallurgy Forging Design-CAM

Problem: In the overall process design for P/M forging, preform design is most difficult and relies on a trial-and-error approach.

Solution: Computer analysis of stresses and flow patterns and computer graphic techniques will aid in preform design.

8044	1	73	240	Completed
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Project Engr: G. Gorline  
Autovon: 693-1625  
Commercial: (314) 263-1625

Title: Simultaneous Gear and Tool Fabrication - CAM Related

Problem: Part Programming for Numerical Control Machine tools was done by manual programming and with computer assisted UNIAPT. This is time consuming and inefficient.

Solution: Interactive graphics system (CAD/CAM) was installed for quick NC tape preparation and as a tool design aid. Interface developed to digitizer/plotter.

400 CAD/CAM INTERACTION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
8125	1	73	274	Completed

Project Engr: G. Gorline  
Autovon: 693-1625  
Commercial: (314) 263-1625

Title: Automated Technical Data Conversion Process

Problem: Flat templates, as tooling and components were fabricated from drawings and sketches. Mainenance and archiving of drawings was costly and ineffective.

Solution: Closed circuit television connected to digitizer/plotter through minicomputer was installed. Digitizing of components and drawings speeds documentation process.

8154	1	75	182	Completed
		81	337	Apportionment

Project Engineer: G. Gorline  
Autovon: 693-1625  
Commercial: (314) 263-1625

Title: CAD/CAM of Extrusion Dies for Aluminum, TI and Steel Parts

Problem: Numerical Control machine tools offer many advantages over conventional machine tools but have certain disadvantages. One problem area is getting machine instructions to the machine tool and collecting management information.

Solution: Interface In-house computer facilities with current and future NC machine tools to form an advanced computer integrated mfg. system. Utilize DNC technology.

500 PLANNING AND GROUP TECHNOLOGY  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
1021	R	80 81	240 250	Approved Apportionment
<p>Project Engr: R. Kotler            Autovon: 746-2065            Commercial: (205) 876-2065</p> <p>Title: CPPP Machined Cylindrical Parts</p> <p>Problem: Present manual method for production process planning of machined cylindrical metal components are inadequate due to high process planning costs and a lack of standardization</p> <p>Solution: Develop a computer software system for process planning of machined cylindrical parts. The system will be manufacturer-independent and will incorporate process decision modeling.</p>				
3232	3	7T 76	245 100	Completed Completed
<p>Project Engr: R. Kotler            Autovon: 746-2065            Commercial: (205) 876-2065</p> <p>Title: Computerized Production Process Planning</p> <p>Problem: Operating present manufacturing systems requires extensive process planning effort. Preproduction operations are such that their completion takes long periods of time.</p> <p>Solution: Computer aided production planning can be used to replace the manual approach to achieve efficiency.</p>				
7430	6	75	300	Completed
<p>Project Engr: S. Hart            Autovon: 880-3721            Commercial: (201) 328-3721</p> <p>Title: Fire Control Manufacture Modernization Plan</p> <p>Problem: Production of modern fire control optics are largely hand operations performed by skilled labor, which is becoming scarce or extinct.</p> <p>Solution: Develop computer controlled processes in many areas of fire control optics and electronics. Develop rapid response spare parts capability.</p>				



500 PLANNING AND GROUP TECHNOLOGY  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
7724	6	79 81	83 224	Approved Apportionment
Project Engr: V. Montuori Autovon: 974-4170 Commercial: (518) 266-4170				
Title: Group Technology of Weapon Systems				
Problem: There is a need to reduce and control the proliferation of parts and designs for items manufactured at Watervliet Arsenal.				
Solution: The Army has purchased a group classification and coding software package. Once this system is implemented, it should be possible to reduce the number of different parts thru standardization.				
7949	6	79 80	127 155	Approved Approved
Project Engr: J. Wilkins Autovon: 793-5897 Commercial: (309) 794-5897				
Title: Application of Group Technology to RIA Mfr. (CAM)				
Problem: Present planning, scheduling, and manufacture of weapon assemblies and components are by separate lots and parts which require multiple machining operations, set-ups and changes of tooling, and cause loss of time and money.				
Solution: Apply group technology to classify, code and manufacture weapon assemblies and components as families-of-parts. Match parts by contour and size for simultaneous machining and sub-group for more efficient machining and assembly.				

500 PLANNING AND GROUP TECHNOLOGY  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
7963	6	79	188	Approved
		80	303	Approved

Project Engr: N. Scott  
 Autovon: 880-6430  
 Commercial: (201) 328-6430

Title: Group Technology plus Cellular Mfg for Fire Components and Assemblies

Problem: Fire control manufacturing resulted in the proliferation of manufacturing information, long set-up times or multiple resetting of machines, under utilization of machines, long and uncertain throughput times, and high work-in progress.

600 MANUFACTURING CONTROL  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
3268	R	78	450	Completed
		79	450	Approved
Project Engr: L. Woodham				
Autovon: 746-1572				
Commercial: (205)876-1572				
Title: Automatic Control of Plating (CAM)				
Problem: The baths used for plating printed wiring boards have an extremely large number of variables which influence PCB quality. If any variable drifts out of relatively narrow bounds, impaired quality results.				
Solution: Develop centralized controller system which will sense multiple inputs, keeping process parameters in balance.				
4284	4	70	8	Completed
		76	160	Completed
Project Engr: S. Bernhardt				
Autovon: 880-3857				
Commercial: (201) 328-3857				
Title: Programmable Fluidic Control System for Lap Machinery				
Problem: Need to provide engineering effort to incorporate modern fluidic control techniques into a wide range of lap equipment.				
Solution: Efforts directed toward evaluation of available fluidic systems and components and preparing a handbook to be used in the preparation of scopes of work and contract awards for units of a prototype system.				
7248	6	73	112	Completed
		74	112	Completed
		75	172	Completed
Project Engr: D. Ippolito				
Autovon: 974-5719				
Commercial: (518) 266-5719				
Title: Improved Manufacturing Control Through Data Automation-CAM Related				
Problem: Slow response of planning, estimating, scheduling and controlling of production functions to meet demands of a rapidly changing manufacturing environment.				
Solution: Develop a computer based production planning and control system.				

600 MANUFACTURING CONTROL  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
7580	6	75	260	Completed
		76	350	Approved

Project Engr: S. Macomber  
 Autovon: 793-6316  
 Commercial: (309) 794-6316

Title: Pilot Auto Shop Loading and Control System - CAM

Problem: A more effective system is required for shop loading and control of production. The system should be more responsive to schedule changes.

Solution: Install a computerized system for control of production scheduling of shop orders. Current status information will be available thru random access. Employ priority sequencing.

600 MANUFACTURING CONTROL  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
8015	6	78	1,046	Approved
		79	12,896	Approved
		80	30,964	Approved
		81	30,239	Apportionment
		82	37,290	Budget
		83	24,891	Pre-Budget
		84	16,754	Pre-Budget

Project Engr: J. Spencer  
 Autovon: 974-4252  
 Commercial: (518) 266-4252

Title: MOD - Cannon Prod Base

Facility: Watervliet Arsenal

700 ASSEMBLY  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
4105	5	7T	225	Completed
		73	105	Completed
Project Engr:	C. Carnali	74	477	Completed
Autovon:	880-4162	75	525	Completed
Commercial:	(201) 328-4162	76	685	Completed
		77	1385	Completed

Title: Auto Increment Ldg + Assy of Prop Chg w/Central Core Igniters

Problem: All prop charges with center core igniters are loaded manually and have high labor costs, and personnel exposure.

Solution: Design, fabricate and prove-out machinery to automatically prop charges.



700 ASSEMBLY  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
2694	5	80	19,560	Approved

Project Engr: J. Bomengen  
 Autovon: 880-6791  
 Commercial: (201) 328-6791

Title: EXP - 155mm/8" Ctr Core Prop Chg LAP

Facility: Indiana AAP

0012	5	79	1,224	Approved
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Project Engr: J. Bomengen  
 Autovon: 880-6791  
 Commercial: (201) 328-6791

Title: IPF - LAP Artillery Propelling Chg

Facility: Crane AAA

800 SIMULATION, MODELING AND OPERATIONS RESEARCH  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
6682	5	79	170	Approved

Project Engr: W. O'Neill  
Autovon: 880-3596  
Commercial: (201) 328-3596

Title: Simulation of Aummunition Production Lines

Problem: Methods are needed for designing production lines operating in a real environment and subject to the uncertainties associated with machine breakdowns and scheduled maintenance.

Solution: Use computer program to develop simulations of the operation of model line modules for production base modernization + expansion.

900 MATERIALS HANDLING AND STORAGE  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
1155	5	73	175	Completed
<p>Project Engr: J. Abbott            Autovon: 584-3418            Commercial: (301) 328-3418</p> <p>Title: Appl Study of Programmable Industrial Robots F/PROD/DEMIL/DEMIL PR</p> <p>Problem: The handling of hazardous munitions and munitions components was done manually. This presents a safety problem.</p> <p>Solution: The automation of the handling of hazardous material can be accomplished through the use of robots.</p>				
7928	6	80 81	113 287	Approved Apportionment
<p>Project Engr: V. Montuori            Autovon: 974-4170            Commercial: (518) 266-4170</p> <p>Title: Robotized Benching Operations</p> <p>Problem: Benching operations on breechblocks and rings are unsafe and time consuming.</p> <p>Solution: Develop industrial robot to perform these operations.</p>				

1000 TEST, INSPECTION AND EVALUATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
3169	R	77 80	275 90	Approved Approved
Project Engr: R. Brown Autovon: 746-5742 Commercial: (205) 876-5742				
Title: Auto Optical Inspection of PC Board + Components (CAM)				
Problem: Operator fatigue allows many bad PCBs to pass visual inspection.				
Solution: Provide an automated optical comparator to eliminate the need for human inspector.				
9353	2	71	1200	Completed
Project Engr: J. Kelly Autovon: 992-3276 Commercial: (201) 532-3276				
Title: Auto. Examination of Electronic Components and Systems				
Problem: The complexity and sophistication of new electronic equipment and components present testing dilemmas. Time and cost limitations mandate testing of a sampling of the specified parameters. Reliability requirements mandate a higher level of inspection, in terms of frequency of end items tested and individual component testing with a system.				
Solution: Automatic Test Equipment will be established using a dedicated computer system. Input voltages will be applied under computer control to the unit under test; the computer will analyze the output signal and determine acceptance of unit under test.				

1000 TEST, INSPECTION AND EVALUATION  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
9773	2	76	193	Completed
		78	500	Approved

Project Engr: R. Zelenka

Autovon: 992-5676

Commercial: (201) 532-5676

Title: Computer Aided F/Prep of Auto Analog Circuit Production Test Program

Problem: Industry does not possess programs to validate the test programs required to test analog circuits.

Solution: Prepare a testing program that will validate and evaluate analog test programs.

1100 CONTINUOUS FLOW PROCESSES  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
4147	5	70	1252	Completed
		74	901	Approved
Project Engr: R. Goldstein				
Autovon: 880-4122				
Commercial: (201) 328-4122				
Title: Computer Control Application to Continuous TNT Manufacture				
Problem: Production of TNT in Government owned plants is being pushed beyond their original design capacity. Control is accomplished through manual procedures.				
Solution: Update TNT manufacture by replacing existing batch plant capabilities with modern continuous lines. Design a prototype direct digital control system for a continuous TNT line.				
4202	5	7T	282	Completed
		70	700	Completed
		71	160	Completed
		72	2520	Completed
Project Engr: L. Lempicke				
Autovon: 880-3637				
Commercial: (201) 328-3637				
		73	1005	Completed
		75	342	Completed
		76	140	Completed
		77	505	Completed
Title: Prototype Equipment F/ Control Automatic Production of Solvent-Type Multi-Base Propellant				
Problem: The present process is entirely manual. It is very hazardous and contributes substantially to air and stream pollution.				
Solution: Meet prescribed procurement objectives with a substantial reduction in cost, hazard exposure and pollution.				



1100 CONTINUOUS FLOW PROCESSES  
MANUFACTURING METHODS AND TECHNOLOGY EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
4303	5	76	363	Completed
		77	60	Completed

Project Engr: J. Allen  
Autovon: 880-3212  
Commercial: (201) 328-3212

Title: Acceptance of Continuously Produced Black Powder

Problem: The lack of a quality assurance system in a continuous process which defines and assures reliable performance of black powder in end item use.

Solution: Improve the accuracy and rapidity of assessment and insure desired quality by identifying and controlling all important source material and process parameters.

1100 CONTINUOUS FLOW PROCESSES.  
FACILITIES EFFORTS

EFFORT NO.	COMMAND CODE	FY	COST	CYCLE
2084	5	73 74	9,296 23,186	Approved Approved
Project Engr: R. Collins Autovon: 880-3651 Commercial: (201) 328-3651  Title: EXP - Black Powder Mfg. Plant  Facility: Indiana AAP				
2875	5	80	98,525	Approved
Project Engr: L. Laibson Autovon: 880-2822 Commercial: (201) 328-2822  Title: CAMBL I (Hybrid)  Facility: Radford AAP				
2899	5	86	192,600	Pre-Budget
Project Engr: L. Laibson Autovon: 880-2822 Commercial: (201) 328-2822  Title: EXP - CAMBL (Hybrid) Line 2  Facility: Sunflower AAP				
5901	5	75	10,878	Approved
Project Engr: A. Keyes Autovon: 880-6751 Commercial: (201) 328-6751  Title: MOD - Restoration of B & C Lines TNT  Facility: Radford AAP				

**APPENDIX B**  
**COMPUTER AIDED MANUFACTURING**  
**STEERING GROUP MEMBERS**

COMPUTER AIDED MANUFACTURING  
STEERING GROUP MEMBERS

DARCOM

US Army Materiel Development and Readiness Command  
Attn: DRCMT, Mr. Frederick J. Michel  
5001 Eisenhower Avenue  
Alexandria, VA 22333

AV: 284-8298/8299  
C: (703) 274-8298/8299

DARCOM

US Army Materiel Development and Readiness Command  
Attn: DRCPP-IF, Mr. Steve Linke  
5001 Eisenhower Avenue  
Alexandria, VA 22333

AV: 284-8225/8226  
C: (703) 274-8225/8226

IBEA

US Army Industrial Base Engineering Activity  
Attn: DRXIB-MT, Mr. Steve McGlone (Chairman)  
DRXIB-F, Mr. James Dewoody  
DRXIB-F, Mr. Wil Ensenat  
Rock Island, IL 61299

AV: 793-3734  
AV: 793-5617  
AV: 793-6226  
C: (309) 794-3734/5617

ARRADCOM

US Army Armament Research Development Command  
Attn: DRDAR-TSF-P, Mr. Stanley Hart  
Dover, NJ 07801

AV: 880-3721/3472  
C: (201) 328-3721/3472

ARRADCOM

US Army Armament Research Development Command  
Attn: DRDAR-CLJ-B, Mr. Kenneth A. Coulson  
Chemical Systems Laboratory  
Aberdeen Proving Ground, MD 21010

AV: 584-3350  
C: (301) 328-3350

ARRCOM

US Army Armament Materiel Readiness Command  
Attn: DRSAR-MSE, Mr. Thomas Frandsen  
DRSAR-IRW-T, Mr. Gerald L. Hall  
Rock Island, IL 61299

AV: 793-4701  
AV: 793-5590  
C: (309) 794-4701/5590

AVRADCOM

US Army Aviation Research and Development Command  
Attn: DRDAV-EXT, Mr. Daniel Haugan  
P. O. Box 209  
St. Louis, MO 63166

AV: 693-1625  
C: (314) 263-1625

CORADCOM

US Army Communications Research and Development Command  
Attn: DELEW-PE, Mr. James F. Kelly  
Fort Monmouth, NJ 07703

AV: 992-3276  
C: (201) 532-3276

COMPUTER AIDED MANUFACTURING  
STEERING GROUP MEMBERS (CONT.)

DESCOM

US Army Depot System Command  
Sacramento Army Depot  
Attn: SDSSA-R(NC/CAM), Mr. Russel Harris AV: 839-2518  
Sacramento, CA 95813 C: (916) 388-2518

ERADCOM

Harry Diamond Laboratories  
Attn: DELHD-IR, Mr. Robert Rosen AV: 290-2917  
DELHD-I-RM, Mr. Harry Hill (Alternate) AV: 290-3124  
2800 Powder Mill Road C: (301) 394-2917/3124  
Adelphi, MD 20783

MERADCOM

US Army Mobility Equipment Research and Development Command  
Attn: DRDME-DE, Mr. Bernard J. Bretz AV: 354-5371  
Fort Belvoir, VA 22060 C: (703) 664-5371

MICOM

US Army Missile Command  
Attn: DRSMI-EAT (RND), Mr. Bobby Austin AV: 746-7057  
DRSMI-EAT (RND), Mr. Richard A. Kotler (Alternate) AV: 746-2065  
Engineering Laboratory C: (205) 876-7057/2065  
Redstone Arsenal, AL 35809

NARADCOM

US Army Natick Research and Development Command  
Attn: DRDNA-EM, Mr. Irving Tarlow AV: 955-2360  
Natick, MA 01760 C: (617) 653-1000

TACOM

US Army Tank-Automotive Command  
Attn: DRDTA-RCKM, Mr. Sam Goodman AV: 273-1814/2065  
DRSTA-ICC, Mr. Chester Zack AV: 273-3011  
DRSTA-ICC, Mr. John DeBolle (Alternate) AV: 273-3016  
Warren, MI 48090 C: (313) 573-1814/3011

TSARCOM

HQ, US Troop Support & Aviation Materiel Readiness Command  
Attn: DRSTS-PLP-(2), Mr. James R. Corwin AV: 693-0496/3366  
DRSTS-PLP-(2), Mr. Arthur Goldberger (Alternate) AV: 693-0496/3366  
4300 Goodfellow Boulevard C: (314) 263-0496/3366  
St. Louis, MO 63120

COMPUTER AIDED MANUFACTURING  
STEERING GROUP MEMBERS (CONT.)

Arsenals

Rock Island Arsenal

Attn: SARRI-AOE, Mr. Richard Johnson  
Rock Island, IL 61299

AV: 793-5528  
C: (309) 794-5528

Rocky Mountain Arsenal

Attn: SARRM-TOI, Mr. Dave Strang  
Denver, CO 80240

AV: 556-2201  
C: (303) 288-0711 ext. 201

Watervliet Arsenal

Attn: SARWV-ODP-S, Mr. Dominick Ippolito  
SARWV-ODP-S, Mr. George Anderson (Alternate)  
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AV: 974-5719  
C: (518) 266-4610 ext. 5719

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Indiana Army Ammunition Plant

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Charlestown, IN 47111

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C: (812) 282-8961 ext. 7403

Iowa Army Ammunition Plant

Attn: SARIO-EN, Mr. George H. Mathes  
Middleton, IA 52638

AV: 585-7101  
C: (319) 754-5731 ext. 710

Lone Star Army Ammunition Plant

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Texarkana, TX 75501

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Radford Army Ammunition Plant

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SARRA-EN, Mr. Gene Rhodes (Alternate)  
Radford, VA 24141

AV: 931-8641  
AV: 931-8641  
C: (703) 639-8641

Riverbank Army Ammunition Plant

Attn: SARRB-ER, Mr. Don Keith  
Riverbank, CA 95367

AV: 463-4236  
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Scranton Army Ammunition Plant

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C: (717) 342-7801 ext. 302

Volunteer Army Ammunition Plant

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Chattanooga, TN 37401

AV: 431-3750  
C: (615) 892-0115



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SDSCC-MPDT, Mr. E. V. Garcia (Alternate) AV: 861-2423  
Corpus Christi, TX 78419 C: (512) 939-3243/2423

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SESLE-MM, Mr. Barton Patterson (Alternate) AV: 242-7475  
Chambersburg, PA 17201 C: (717) 263-7693/7475

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Sacramento, CA 05913 C: (916) 388-3378

Tobyhanna Army Depot  
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Tooele, UT 84074 C: (801) 833-2789

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Dover, NJ 07801 C: (201) 328-6704

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Attn: DRXOM-SE, Mr. Alvin K. Takemoto AV: 793-4041  
DRXOM-SE, Mr. James O. Young (Alternate) AV: 793-4041  
Rock Island, IL 61299 C: (309) 794-4041

US Army Materials and Mechanics Research Center (AMMRC)  
Attn: DRXMR-ER, Mr. Roger Gagne AV: 955-3436  
Watertown, MA 02172 C: (617) 923-3436

## **APPENDIX C**

### **DARCOM CAD/CAM SYSTEMS**

# DARCOM MINICOMPUTER INTERACTIVE DESIGN SYSTEMS

## EXISTING SYSTEMS

<u>LOCATION</u>	<u>TURNKEY VENDOR</u>	<u>POINT OF CONTACT</u>
ARRADCOM, Aberdeen, MD	Info Displays Inc (IDI)	V. Pearl AV 584-2918 (301) 671-2918
ARRADCOM, Dover, NJ	United Computing Corp.	S. Hart AV 880-3721 (201) 328-3721
ARRADCOM, Watervliet, NY	Gerber	V. Montuori AV 974-4170 (518) 266-4170
ARRADCOM, Watervliet, NY	Lundy	V. Pascale AV 974-5706 (518) 266-5706
CERCOM, Ft. Monmouth, NJ	IDI	J. Demco AV 992-2992 (201) 544-2992
CORADCOM, Ft. Monmouth, NJ	Gerber	M. Kosmin AV 995-4267 (201) 544-4267
DESCOM, Corpus Christi, TX	United Computing Corp.	F. Gross AV 861-2423 (512) 939-2423
ERADCOM, Adelphi, MD	Computervision	H. Hill AV 290-3124 (301) 394-3124
ERADCOM, Adelphi, MD	Adage	R. Rosen AV 290-2917 (301) 394-2917
ERADCOM, Ft. Monmouth, NJ	Applicon	R. Reitmeyer AV 995-4769 (201) 544-4769
ERADCOM, Ft. Belvoir, VA	Tektronix	R. Oswald AV 354-1611 (703) 664-1611
MICOM, Huntsville, AL	M&S	R. Epps AV 746-3524 (205) 876-3524
NARADCOM, Natick, MA	Hughes	N. Rodill AV 995-2046 (617) 653-1000

# DARCOM MAIN FRAME COMPUTERS<sup>1</sup>

SUBMACOM	MAIN FRAME	CAD/CAM <sup>2</sup>
ARRADCOM		
CSL, Aberdeen, MD	UNIVAC	X
HQ, Dover, NJ	CDC	X
BRL, Aberdeen, MD	CDC	-
BWL, Watervliet, NY	IBM	X
ARRCOM, Rock Island, IL	IBM	X
AVRADCOM, St. Louis, MO	IBM	-
CERCOM, Ft. Monmouth, NJ		-
CORADCOM, Ft. Monmouth, NJ	IBM	-
DESCOM, Chambersburg, PA		-
ERADCOM		
HQ, Adelphi, MD	IBM	X
MERADCOM, Ft. Belvoir, VA	IBM	-
MICOM, Huntsville, AL	CDC	-
NARADCOM, Natick, MA	UNIVAC	X
TACOM, Warren, MI	Time Share ARRADCOM, Dover, NJ	
TECOM, Aberdeen, MD	Time Share ARRADCOM (BRL) Aberdeen, MD	
TSARCOM, St. Louis,		-

## NOTES:

1. Reference - Inventory by Data Processing Installation (AMCR 18-5)
2. X: indicates CAD/CAM capability currently exists or is in use.  
 -: indicates CAD/CAM capability does not exist or is not in use.

## **APPENDIX D**

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HQDA, ODCSRDA, The Pentagon, Attn: DAMA-PPM-P, Mr. Rod Vawter  
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DCSRDA, Attn: DAMA-WSM-A, Mr. John Doyle  
DCSRDA, Attn: DAMA-WSW, MAJ Gordon Winder  
DCSRDA, Attn: DAMA-CSC-BU, COL Higgins  
DCSRDA, Attn: DAMA-CSS-P, LTC L. R. Hawkins, LTC P. K. Linscott  
DCSRDA, Attn: DAMA-CSM-P, Mr. John Mytryshyn  
DCSRDA, Attn: DAMA-CSM-DA, COL Jack King

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Cdr, DARCOM, Attn: DRCMDM  
Cdr, DARCOM, Attn: DRCDMR  
Cdr, DARCOM, Attn: DRCPP  
Cdr, DARCOM, Attn: DRCPP-I (3 cys)  
Cdr, DARCOM, Attn: DRCDE  
Cdr, DARCOM, Attn: DRCMT (20 cys)  
Technical Library, Attn: DRXAM-L

AVRADCOM:

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PM, Blackhawk, Attn: DRCPM-BH  
Cdr, Attn: DRDAV  
Cdr, Attn: DRDAV-EXT, Mr. Robert Vollmer  
Technical Library, St. Louis, MO  
Cdr, AMRDL, Attn: SAVDL-EU-TAS, Mr. L. Thomas Mazza

ARRADCOM:

PM, Cannon Artillery Weapons Systems, Attn: DRCPM-CAWS  
PM, Division Air Defense (DIVAD) Gun, Attn: DRCPM-ADG  
PM, Nuclear Munitions, Attn: DRCPM-NUG  
PM, Selected Ammunition, Attn: DRCPM-SA  
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Cdr, Attn: DRDAR-PML, Mr. Donald J. Fischer (7 cys)  
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PM, Smoke/Obscurants (SMOKE), Attn: DRCPM-SMK  
Cdr, Attn: STEAP-MT-M, Mr. J. L. Sanders

ARRCOM:

PM, M110E2 Weapon System, Attn: DRSAR-HA  
Cdr, Attn: DRSAR-CG  
Cdr, Attn: DRSAR-IRB, Mr. August Zahatko (4 cys)  
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Cdr, Attn: DRSAR-LEP, Mr. R. F. Tumasonis  
Technical Library, Attn: DRSAR-LEP-L

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Dir, Attn: DRXMR-PMT, Mr. Raymond Farrow  
Dir, Attn: DRXMR-E0, Dr. Morton Kliman  
Dir, Attn: DRXMR, DRXMR-M (3 cys ea)  
Technical Library, Watertown, MA

CERCOM:

PM, Signal Intelligence/Electronic Warfare (SIGINT/EW), Attn: DRCPM-SIEW  
Cdr, Attn: DRSEL  
Cdr, Attn: DRSEL-LE-R, Mr. Martin Ides

CORADCOM:

PM, Army Tactical Communications Systems (ATACS), Attn: DRCPM-ATC  
PM, Automatic Test Support Systems, Attn: DRCPM-ATSS  
Cdr, Attn: DRDCO  
Cdr, Attn: DRDCO-PPA-TP, Messrs. Feddeler, Esposito, Resnic (1 cy ea)  
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Cdr, Attn: DRSDS-PE, Mr. Jim Shindle

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PM, FIREFINDER, Attn: DRCPM-FF  
PM, Remotely Monitored Battlefield Sensor Systems (REMBASS), Attn: DRCPM-RBS  
PM, Stand-off Target Acquisition System, Attn: DRCPM-STA  
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Cdr, Attn: DELET-R, Messrs Key, Reich (1 cy ea)  
Cdr, Attn: DRDEL-ED, Mr. Harold Garson

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PM, Mobile Electric Power, Attn: DRCPM-MEP (Springfield, VA)  
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PM, HAWK, Attn: DRCPM-HA  
PM, Heliborne Laser Fire and Forget (HELLFIRE) Missile System,  
Attn: DRCPM-HE  
PM, High Energy Laser System, Attn: DRCPM-HEL  
PM, PATRIOT, Attn: DRCPM-MD  
PM, 2.75 Rocket System, Attn: DRCPM-RK  
PM, STINGER, Attn: DRCPM-MP  
PM, TOW-DRAGON, Attn: DRCPM-DT  
PM, US ROLAND, Attn: DRCPM-ROL  
PM, VIPER, Attn: DRCPM-VI  
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PM Armored Combat Vehicle Technology (ACVT), Attn: DRCPM-CVT  
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PM, Fighting Vehicle Systems, Attn: DRCPM-FVS  
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PM, Improved TOW Vehicle, Attn: DRCPM-ITV  
PM, XM-1 Tank System, Attn: DRCPM-GCM  
Cdr, Attn: DRSTA  
Cdr, Attn: DRSTA-EB, Ms Vivian Buarkhalter  
Cdr, Attn: DRDTA-KP, DRDTA-RCK, Mr. J. Chevalier  
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Technical Library, Yuma, AZ

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